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ADVANCED FIREPOWER CONCEPTS FOR MILITARY OPERATIONS IN BUILT-UP AREAS. VOLUME I

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Ketron, Incorporated

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VOLUME I

TECHNICAL REPORT

ADVANCED FIREPOWER CONCEPTS FOR MILITARY OPERATIONS IN BUILT-UP AREAS

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I. SUMMARY

I.1 Background

With the increasing importance of the city in both developed and developing nations, a growing segment of the professional military and political community have come to agree that our military force structure and operational doctrine need modification to improve our capabilities to cope satisfactorily with conflict situations in built-up areas. A fundamental assessment of the qualitative and quantitative suitability of our current developmental weapon systems and tactics for the achievement of military goals under political constraints in the environment of the city has been a pressing requirement.

I.2 Objective

this report,

The objective of this study is to identify the needs and evaluate system alternatives for improved firepower capabilities of military forces for operations in built-up areas overseas.

I.3 Task Requirements

To guide the research program, four major task requirements were defined and pursued throughout the analysis.

I.3.1 Analysis of Current Firepower Capabilities

Investigate the capabilities and limitations of available firepower systems and associated standard user doctrines.

I.3.2 Interface with Communication, Surveillance, Mobility, and Civil Interaction

Identify the operational interdependencies and physical interfaces linking Firepower functions with the Communication, Surveillance, Mobility, and Civil Interaction functions.

I.3.3 Development of New System Candidates

Identify and define new and original approaches and designs to satisfy deficiencies found in current firepower capabilities.

I.3.4 System Recommendations

Select new firepower system candidates for further concept formulation effort on the basis of expected tactical utility, preliminary technical feasibility evaluations, and cost-benefit analysis.

I.4 Technical Approach

This report is based on two major investigative methodologies. One methodology consists of historical case analyses of significant instances of military operations that have occurred in cities around the world. The second major methodology is centered upon the development and application of Technical Problem Resumes (TPRs) based upon specific city combat scenarios as major analytic vehicles for firepower system evaluation and concept development. The paragraphs below contain brief descriptions of these methodologies and outline their application to the task requirements.

I.4.1 Historical Case Analyses of Past Military Operations in Built-Up Areas

Important instances of urban conflict were examined to identify and extract the firepower problems experienced by commanders in the past. An extensive search of military source literature was made, and numerous conferences and interviews were conducted with knowledgeable commanders and military scientists.[1] Thirty-two primary examples of combat in built-up areas were isolated and reviewed. Significant historical observations were extracted, processed, and quantified to develop a data base describing the overall relationships among force structures, operational concepts, and combat mission performance in previous urban military operations. Products of this analysis provided indications of basic gaps and notable limitations in current firepower capabilities in built-up areas and suggested improved operational and materiel concepts.

1/ A listing of documents consulted is found in APPENDIX D: BIBLIOGRAPHY of the Final Technical Report. APPENDIX B: CITY COMBAT EXPERIENCE provides one example of conferences and interviews conducted.

I.4.2 Development and Application of Technical Problem Resumes

Scenarios depicting military operations in six representative urban areas around the world were provided by GTE Sylvania, the coordinating contractor for this contractual effort. Using these scenarios as a general basis, detailed tactical mission requirements were developed and analyzed to determine the capabilities and limitations of current firepower systems. These scenarios also supported a limited examination of the operational and mechanical interfaces of firepower with the Mobility, Communications, Surveillance, and Civil Interaction functions and equipment. The basic scenarios were then expanded to provide the more detailed, higher resolution firefight descriptions in which tasks performed by individual fire teams and weapons crews were delineated and evaluated for comparative mission effectiveness in a variety of tactical combat actions.[2/] These detailed scenarios provided the analytical forms and structure for the subsequent development of new firepower system concepts and the formulation and validation of recommended system characteristics. The outputs from the detailed scenario analyses were structured into product documents consistent with the Technical Problem Resume format.

I.5 Findings and Recommendations

Findings and recommendations produced by this research project are presented below.

I.5.1 Findings and Recommendations Related to Historical Experience

These findings and recommendations are derived from the investigation and evaluation of actual military operational experience in built-up areas.

2/ These enhanced scenarios are contained in APPENDIX A: TECHNICAL PROBLEM RESUMES.

FINDINGS	RECOMMENDATIONS
(a) Conventional airborne firepower has had limited tactical support value due to close quarters of urban combat operations and the vulnerability of hovering and low speed aircraft.	(a) Doctrine, tactics, and weapons for use by helicopters in an urban environment show promising potential and should be developed in greater detail by Army and Marine Corps concepts agencies.
(b) Direct short-range fire by tanks and large caliber SP and towed artillery has played an important role in most offensive and some defensive operations.	(b) Doctrine for using direct short-range tank and artillery fire and materiel modifications to improve their survivability in built-up areas should be developed further by appropriate Army and Marine Corps agencies.
(c) The effects of indiscriminate indirect artillery fire and air-delivered munitions upon urban areas has proven to be counterproductive in the past.	(c) Indirect artillery fire and air-delivered munitions should have more precision for use in built-up areas, possibly requiring precision guided munitions (PGMs) and improved fire support coordination capabilities along the lines developed in this report.
(d) Movement in the streets and in the hallways of buildings is extremely dangerous and indicates a need for a readily available wall-breaching capability.	(d) The Army Materiel Command should be encouraged to develop wall-breaching devices and munitions for employment at the small unit level to meet the needs of urban combat.
(e) Significant differences exist between U.S. and Soviet doctrine and tactics for the penetration and	(e) Modification of U.S. doctrine and tactics for the attack of built-up areas should be considered for both

destruction of city defenses with armor, artillery, and infantry. the attack of built-up areas and the defense of cities such as those in Western Europe.

I.5.2 Findings and Recommendations Regarding Selected Weapon Systems and Tactics

These findings and recommendations are derived primarily from analyses of basic and expanded scenarios depicting military operations in built-up areas.

Individual/Personal Weapons Findings

FINDINGS	RECOMMENDATIONS
(a) The operational requirements associated with the employment of individual weapons in an urban environment differ greatly from those experienced in standard field operations. Engagement ranges are much shorter, target exposure is severely limited in time and space, and urban structures provide readily available protection.	(a) The capabilities of current individual weapon systems should be expanded to include considerations of employment in built-up areas and trade-offs with nonurban requirements. The urban operational requirements should be developed in detail and applied in the selection of the next generation of individual weapons.
(b) Current small arms ammunition is not adequately effective against structural materials when fired at the close ranges encountered in city combat.	(b) The mechanisms of small caliber bullet perforation of urban structures should be determined, and small arms projectile design changes should be considered for possible improvement of close range performance.
(c) Reduction of civilian casualties is desired, but the development of	(c) Operational methods of reducing civilian casualties should be exam-

new weapons having selective lethality or reliable nonlethal incapacitation capability is not considered to be a feasible alternative to current small arms within the 1975-80 time frame. Nevertheless, there is still a potential for special munitions for the individual weapon capable of delivering incapacitating effects.

(d) Unaimed fire at targets of opportunity at close ranges is much more common in urban combat then elsewhere.

(e) The resupply problems and the lengthy duration of firefights in the urban environment emphasize the importance of the individual's ability to carry an adequate basic load for his weapon.

(f) The development of a special individual weapon for city fighting is technically feasible. The development of a light submachine

ined in lieu of the development of new weapon systems designed for selective lethality or nonlethal incapacitation capabilities. The technical feasibility and logistical implications of providing special incapacitating munitions for existing systems warrant more detailed evaluation by the appropriate Army agencies.

(d) The salvo squeeze bore (SSB), duplex, and other salvo system concepts warrant consideration for possible urban combat application. These provide trade-off opportunities for improving snapshooting performance at the cost of long-range accuracy and should be assessed by thorough cost-benefit analyses.

(e) Any new individual weapon system and its ammunition component should be light in weight to permit the individual to carry large numbers of rounds in his basic load and to move in the close confines of intrabuilding combat.

(f) The development of a weapon concept combining the characteristics of the submachine gun and the multiple projectile cartridge should be con-

gun employing multiple projectile rounds appears to be a method of improving the individual weapon system significantly for urban combat.

sidered for urban combat applications. A thorough analysis should be undertaken to determine the mission advantages vs. the logistical impacts of adopting such a system.

Large Caliber Squad Weapons--Wall Breachers

(a) Current weapons systems are not adequate for wall-breaching, and the need for significantly improved wall-breaching capability warrants high priority.

(a) Special emphasis should be placed on man-portable wall-breaching systems both for building entry and room-to-room movement. It is recommended that exploratory development efforts be undertaken according to the recommendations in this study.

(b) Additional data and information are required on current weapon systems in order to properly employ our present capabilities. Data are required primarily in the areas of terminal effects and the launch environment of urban combat.

(b) Determination of terminal effects for current munitions against city structures should be made and user doctrine for these munitions developed.

(c) Significant improvement in present capabilities appears feasible through redesign (product improvement) of existing warheads and development of alternative payloads for present systems.

(c) Development of alternative warheads (especially HEP) for current munitions should be undertaken and related acquisition policies re-evaluated.

Large Caliber Squad Weapons

(a) The infantryman in a built-up area frequently needs to deliver relatively large payloads to close-in targets. Current U.S. weapon systems capability does not satisfy this requirement.

(b) Present U.S. rockets and recoilless weapons developed for land combat are of limited utility in urban areas. Due to the backblast, they cannot be fired from enclosures without hazard to the operator, nearby friendly personnel, and the surrounding structure.

(c) Present HEAT warheads, while effective in perforating urban structures, are inadequate in behind-the-wall effects. HEP warheads, presently not available for large caliber man-portable weapons, have potential for improvement and use against urban structures.

(a) Concept formulation efforts should be undertaken toward the needs for short-range, large payload man-portable weapon systems in accordance with recommendations developed in this study.

(b) In the highly structured urban terrain there are many features whose mass, structural strength, and geometric regularity can be exploited to absorb the recoil momentum of closed-breech weapons. Recoil transfer mechanism options should be examined for closed-breech weapons.

(c) Testing and analysis of HEAT and HEP warheads should be conducted on selected structural targets to determine improved techniques of employment and to establish the defeat mechanism as a basis for design improvement. Improved warheads should be made available.

Infantry Support Weapons -- Use of Artillery in Cities

(a) U.S. doctrine for the employment of artillery against urban targets lacks specificity regarding the use of artillery in the direct fire role and does not address the counterproductive effects generally produced for the attacker by the employment of extensive indirect artillery fire.

(a) Current doctrine for using artillery against cities should be reviewed and modifications considered with respect to employment in the direct fire mode.

(b) The availability of up-to-date information on the location and disposition of friendly and enemy forces, civilian populations, and key installations is of critical significance in the restricted confines of urban combat. The fire direction center and fire support coordination center may become a valuable data storage and processing source for this information requirement.

(b) The capacity of the fire direction and fire support coordination centers, especially new systems such as TACFIRE, should be analyzed with respect to their ability to meet the commander's need for timely and detailed information on force dispositions and key structural features in combat in built-up areas.

(c) Current HE and HEP rounds are not designed for use against urban structures.

(c) Testing is required to determine current munitions effectiveness against selected classes of structures. New concepts of employment should be developed based on the test results. Warhead design alternatives should be examined with respect to urban combat requirements.

(a) Helicopter gunship fire support has high pay-off potential for prompt attack on defense strongpoints and interdiction of reinforcement elements in many urban combat situations despite the probable high cost of attrition.

(a) Exploratory development should be undertaken in the areas of side-firing or flexibly mounted large caliber weapons, application of PGMs, and application of protective armor in the employment of helicopter fire support to ground units in urban combat situations. Concurrently, more explicit doctrine and tactics should be developed.

(b) Fighter bombers will continue to have a role in many urban battles, especially with the advent of precision guided munitions. However, due to the close ranges of engagement, the accuracy of munitions delivered by fighter bombers will remain only marginally acceptable at best, and the cost of such operations would be extremely high in the sophisticated antiaircraft environment likely to be found in urban combat.

(b) Fighter bombers should continue to be considered as primary means of delivering munition to targets in an urban environment, but the limitations of this kind of aerial fire support should be more fully recognized than in the past. The application of air-launched PGMs in the built-up environment requires more detailed analysis.

(c) Except for the special case of a crucial threat, it is difficult to see remotely piloted vehicles (RPVs) as aerial weapon delivery systems in urban combat. However, in the

(c) The progress of RPV development should be monitored for potential application for target acquisition and PGM designator roles.

roles of target acquisition, forward designator/controller, and damage assessment, the RPV has distinct promise.

Infantry Support Weapons -- Use of Armor in Cities

(a) Despite our doctrine to the contrary, the tank is a key weapon system in urban combat operations. Survivability can be increased by enabling full 360° direct visibility by a tank crew member during the "ride into town." A transparent protective canopy is one obvious possibility.

(a) Exploratory development of a transparent canopy resistant to small arms fire and HE fragments is recommended.

(b) Smoke devices that can produce the persistency and density of smoke required to provide concealment for armor are highly desirable as a means of neutralizing the advantages in visibility accruing to weapon emplacements exploiting indigenous structures for concealment.

(b) Further study should be undertaken to determine optimum densities and persistence characteristics for smoke dispensing systems. Exploratory development of improved vehicular mounted systems to provide the quantities of smoke required should be initiated.

(c) U.S. doctrine for the employment of armor in cities is inadequate in concept and statement.

(c) U.S. doctrine prescribing procedures for using tanks in cities has been reviewed and found to require extensive revision and expansion to exploit its full potential.

Infantry Support Weapons -- Precision Guided Munitions

(a) Precision guided munitions have the potential to provide effective firepower in an indirect mode, but detailed knowledge regarding the applicability of PGMs in an urban environment is not adequate.

(a) A methodology for evaluating PGM performance in urban environments has been outlined in this analysis. Further development and application of the methodology is recommended to determine the combat utility of this asset vis-a-vis conventional munitions for selected specific attack and defense missions.

Infantry Support Weapons -- Off-Route and Scatterable Mines

(a) The current inventory of mines is not suitable for use in the city. Both off-route and scatterable mines would assist in controlling specific areas, canalizing the movement of enemy forces, and slowing the rate of enemy advance. These new concepts appear to be technically feasible and cost-effective for use in urban combat.

(a) The feasibility and tactical utility of scatterable and off-route mines have been indicated in the analysis of given scenarios. A detailed, rigorous study is recommended to evolve concepts of employment and materiel design goals.

Infantry Support Weapons -- Smoke

(a) Smoke and other chemicals capable of providing concealment are of extreme importance in urban combat.

(a) Experiments should be undertaken to measure the performance characteristics of delivery systems

Experience indicates that the current capability for providing smoke is not sufficient in terms of delivery means and concealment effects.

in representative urban environments. This should then be used in the context of stated scenarios as a basis for developing new performance criteria and design goals for smoke munitions and dispensing systems. Preliminary studies should be undertaken for design of a vehicular mounted system to provide the quantities of smoke required.

Infantry Tactical Concepts - Urban Reconnaissance Patrols

(a) Reconnaissance patrols are a primary means of obtaining combat intelligence in the city; yet U.S. doctrine regarding urban reconnaissance patrols is superficial. A comprehensive examination and delineation of mission activities, organization, and equipment for urban reconnaissance patrols has not been developed.

(b) Remotely piloted vehicles hold considerable potential for rapid, three-dimensional reconnaissance in urban environment.

(a) More emphasis is necessary on the employment of urban reconnaissance patrols in built-up areas. An investigation of possible missions for urban reconnaissance patrols and the mixes of personnel and equipment required to accomplish those missions should be undertaken.

(b) RPVs currently under investigation should be evaluated analytically and empirically to determine the feasible limits of their operability in the urban terrain and their value in the target acquisition and damage assessment roles.

Infantry Tactical Concepts -- Air Assault Operations in Urban Areas

(a) Rear area airmobile assaults offer possible alternative options to slow block-by-block clearing of a built-up area. However, the tactics for airmobile offensive operations in cities have not been considered, and it is possible that the geometry of urban structures may force significant modifications upon conventional methods of airmobile assault developed in standard field environments.

(a) An extensive and detailed analysis of helicopter employment in urban airmobile assault operations should be undertaken.

II. TECHNICAL APPROACH

It was recognized several years ago that U.S. military doctrine and materiel (especially for ground combat) remained largely based on the "field" environment. Yet experience showed increasing frequency, complexity, and criticality of combat in urban, or built-up areas. Demographic, political, and military studies clearly emphasize this trend toward city fighting for future military operations. The Office of the Secretary of Defense (OSD) recognized this trend and the makeshift nature of the adaptation of field materiel and tactics to the urban environment. In 1968 IDA performed a study on the subject.

In 1971 OSD convened a panel to follow-up on the IDA study and this led in 1972 to the ARPA-sponsored study of Military Operations in Built-Up Areas (MOBA). The project coordination role was performed by GTE Sylvania and the remaining substantive portions of the study were divided into military functional categories as follows: (1) Firepower by Ketron, Inc., (2) Mobility by Calspan Corp., (3) Surveillance by GTE Sylvania, (4) Communications by GTE Sylvania, and (5) Civil Interaction by Battelle Columbus Laboratories.

During the past year these contractors have analyzed the posture of U.S. forces to conduct military operations in built-up areas overseas and have identified numerous areas in which our capabilities might be improved for this operational context. These studies have generally included examination of past combat, assessments of current force structure and doctrine, evaluations of standard and developmental materiel systems, and critical appraisals of performance in the context of selected urban environment and engagement conditions. The following discussion explains and reviews the general technical approach and specific methodologies and techniques used by Ketron to perform the firepower portion of the MOBA contract research project.

II.1 Objective

The objective of this study is to identify the needs and evaluate system alternatives for improving firepower capabilities for combat operations in built-up areas overseas.

II.2 Methodology Development and Formulation

This report is based upon two major investigative methodologies. The first methodology consists of historical case analyses of significant instances of military combat operations that have occurred in cities around the world. Salient characteristics of these conflicts were analyzed and compared to current U.S. military operational procedures to determine the important doctrinal gaps and materiel deficiencies. The second major methodology is centered upon the development and application of Technical Problem Resumes (TPRs) as major analytic vehicles for firepower system combat performance assessment. Basic scenarios depicting military operations in representative urban areas around the world were provided by GTE Sylvania, the general coordinating contractor for the overall research effort. These scenarios -- first in their primary form and later in expanded and more detailed versions -- were utilized to specify, investigate, and assess the capabilities and limitations of current firepower systems, possible modified employment techniques for standard and developmental items, and proposed product improvements and new weapon system concepts.

II.2.1 Historical Case Analyses of Past Military Operations in Built-Up Areas

Important instances of urban conflict were examined to identify and extract the firepower problems experienced by commanders in the past. An extensive search of military documentation and open source literature was conducted. Numerous conferences and interviews also were held with knowledgeable commanders and scientists. The following primary examples of combat in built-up areas were identified and analyzed:

RIGA	1917	WEISSENFELS	1945*
MADRID	1936	BERLIN	1945
WARSAW	1939	MANILA	1945*
ROTTERDAM	1940	SAN MANUEL	1945*
MOSCOW	1942	VILNA	1946
STALINGRAD	1942	SEOUL	1950*
LENINGRAD	1942	BUDAPEST	1956
WARSAW	1943	BEIRUT	1958*
SICILY	1943	SANTO DOMINGO	1965*
BREST	1944*	SAIGON	1968*
CASSINO	1944*	KONTUM	1968*
WARSAW	1944	HUE	1968*
AACHEN	1944*	BELFAST	1972
ORTONA	1944	MONTEVIDEO	1972
CHERBOURG	1944*	QUANGTRI CITY	1972 (ARVN)
BRESLAU	1945	AN LOC	1972 (ARVN)

* Direct U.S. Troop Involvement

Analyses of urban combat in Aachen and Hue revealed one firepower problem typical of the miscalculations and difficulties experienced by combat commanders attempting to conduct successful combat operations in built-up areas. In both of these cities the urban structure was reduced to rubble by large quantities of indirect artillery fire and air-delivered ordnance in an attempt to clear them of enemy resistance. Careful examination of these two combat operations illustrated that this type of firepower was relatively ineffective in reducing the defenders. Turning the buildings into rubble altered the type of cover available but did not hasten the achievement of the military mission. A large number of firepower problems of similar magnitude were identified in successive case analyses of other selected urban conflict situations.

Significant historical observations regarding firepower problems were extracted, processed, and quantified to develop a data base of variables defining overall relationships among force structures and combat mission accomplishment. Critical variables were identified in a number of historical battles and were arranged as follows:

Conditions	Results
Force sizes and types	Battle duration
Weapon quantities	Rate of advance
Firepower delivered	Casualties by type
City area and population	
Building density	
Weather	

Whenever possible these variables were weighted according to historical fact. Correlations were established if consistencies developed. Products of these analyses provided basic indications of gaps and deficiencies in current firepower capabilities in built-up areas and suggested directions for new weapon concepts and user doctrines.

II.2.2 Technical Problem Resumes

Each of the set of six basic scenarios constructed by GTE Sylvania described a representative urban environment including the civic systems and contending military force structures. General statements of situations and events were also contained in the scenario package. Firepower tactics and general interactions with other combat and support functions were developed from these scenarios.

The scenarios also were used as a basis for developing the details of firepower tactical missions and engagement conditions. The structure and content of individual scenarios were greatly amplified to provide detailed high resolution firefight descriptions in which the actions of separate fire teams and weapon crews were analyzed. The detailed

combat actions developed included blocking and breaching actions, building penetration, room-to-room clearing, street fighting, airport attack and defense, and overall city defense and penetration. Utilizing these actions, individual gun crew and fire team performance of typical urban combat tasks was evaluated. These tasks included short range hasty firing; neutralization of enemy snipers, fire teams, and weapon crews; wall-breaching; barricade defense; and so on.

These performance assessments permitted the identification of the dominant operational needs and the formulation of new firepower system concepts to fill the gaps. Analytic outputs were structured into product documents according to the Technical Problem Resume format shown below:

1. References
2. Description of Problem
3. Recommendations for Further Analysis
4. Situation and Considerations
   a. Tactical Event for Analysis
   b. Characteristics of the Area of Operations
   c. Description of Own Forces
   d. Description of Enemy Forces
5. Problem Analysis
6. Results of Analysis
7. Alternative Responses.

In this format, paragraphs 1, 2, and 4 provide the background for the problem. Paragraph 5 analyzes the problem specifically. Paragraph 6 attempts to resolve the problem either by employment of standard weapon systems or by the synthesis and application of new concepts. In this manner, the problem situation is used to drive the analysis in an attempt to develop concepts which provide significant advantages over current capabilities and methods. Usually, a specific concept was evolved or

problem areas identified. Paragraph 3 contains a description of the unresolved aspects of the problem which require further analysis. Paragraph 7 attempts to define alternative means and concepts to solve the problem.

II.3 Task Definition and Accomplishment

To guide the research program, four major task requirements were defined and executed throughout the analysis.

II.3.1 Analysis of Current Firepower Capabilities

Investigate the capabilities and limitations of available firepower systems and associated standard user doctrines. First level tactical requirements derived from basic scenarios were used to design an extensive data collection effort. The information resources of the Army Materiel System Analysis Agency, Institute for Land Combat, Infantry Agency, Infantry School, Infantry Board, Advanced Materiel Concepts Agency, Institute for Systems Analysis, Land Warfare Laboratory, and Combat Development Command were (among others) carefully searched. Data were collected, validated, organized, and processed to obtain both qualitative and quantitative descriptions of firepower system performance in target engagement conditions most frequently associated with combat in urban areas. These performance profiles provided the basis for the assessment of current weapon capabilities as employed in the specific combat tasks described in amplified combat scenarios.

II.3.2 Interface with Communication, Surveillance, Mobility, and Civil Interaction

Identify the operational interdependencies and physical interfaces linking Firepower functions with the Mobility, Surveillance, Communication, and Civil Interaction functions. Every weapon system must be integrated eventually into the total combat and support organization with which it must react. A series of flow charts depicting courses of action as described in the basic scenarios was prepared as one means of predicting parameters of

complementation. These charts were susceptible to controlled experimental variation and facilitated the qualitative examination of interaction among Firepower functions and Communication, Surveillance, Mobility, and Civil Interaction functions. Successive analyses yielded comparative value outcome data with respect to the demands of the firepower function on the other combat and support systems.

II.3.3 Development of New System Candidates

Identify and define new and original approaches and designs to satisfy deficiencies found in current firepower capabilities. This was a major effort in the research plan and included the amplification of the scenarios with respect to firepower actions and assessment of firepower task capabilities. To produce the required integrated analytic environment, performance profile criteria derived from Task I were applied within the precise, itemized operational simulations generated in the detailed scenarios. Within this environment three significant categories of new concepts were evaluated:

- Alternative doctrines for using current firepower systems
- Additions or modifications to current systems, such as improvements in the ammunition component
- New system concepts suggested by technological trends and scientific development

II.3.4 System Recommendations

Select new firepower system candidates for further concept formulation effort on the basis of expected tactical utility, preliminary technical feasibility evaluations, and cost-benefit analysis. System recommendations were based on integrated analyses of several influencing critical factors: combat situations and tasks, target and threat environmental characteristics, operational effectiveness, technical feasibility, and cost. Each is discussed briefly below.

(1) Combat Situations and Tasks - Representative (most likely) combat situations were selected from the amplified scenarios. Each situation was described in detail and used to evaluate the system candidate.

(2) Target and Threat - Potential threat forces were delineated and from these specific targets were developed against which concept performance was assessed. Normally, targets and threats of the 1975-80 time frame were selected. Tactics and possible tactical changes were assessed and used in the analyses. Appropriate countermeasures available to enemy forces were used also. The scenarios covered a broad spectrum of operations, thus providing rich assessment models.

(3) Environmental Characteristics - From the scenario information and descriptions given, the analyses concentrated on those aspects of the physical structural environment which were related directly to specific characteristics of the concept. For land-based weapons, the types and amounts of cover, ranges, types of construction, and firing angles were among the parameters chosen and used. For helicopters, firing angles, turning radii, street widths, building heights, possible AA unit locations, and approach avenues were included.

(4) Operational Effectiveness - Operational performance measures were synthesized from Task 1, Current Capabilities, and used in this analysis. Appropriate changes were made where possible to assess the improvement afforded by the new and improved concepts. The baseline used for comparative performance evaluation was the current weapon system and method of employment. Each of the concept characteristics such as basic load, emplacement and displacement time, maximum and minimum ranges, rates of fire, and the like, were assessed.

(5) Technical Feasibility - A preliminary technical feasibility analysis was applied to each new or improved concept that survived the operational effectiveness analysis. The methods used were (1) to

evaluate concept characteristics in terms of specific characteristics of existing weapons and (2) to consult specialists and experts in specific technical areas.

(6) Cost Analysis -- Several types of cost estimates were considered for surviving concepts. These included developmental, production, and training costs. Rough estimates were developed using current costs for producing similar equipment with allowances for increased sophistication where applicable.

III. ANALYSIS OF HISTORICAL EXPERIENCE

III.1 Introduction

The basic reason for the destruction of the city is its strength. The defender enjoys great advantages in cover and concealment. A steel-reinforced building becomes a large matrix of pillboxes, each indistinguishable from the other. A street of houses becomes a gantlet of death with a sniper potentially behind every window or opening. Recoilless rifles (RRs), Light Antitank Weapons (LAWs), and flame weapons spell danger even to armored vehicles. U.S. attack doctrine therefore prescribes deliberate house-to-house fighting to secure each street. In each house the attacker may have to engage in room-to-room clearing. At each room he must determine whether defenders or civilians are inside. He can hardly be blamed for liberal use of grenades since entry into a defended room is almost certain death. He finds entry to other buildings virtually impossible unless he brings in heavy firepower. As his casualties mount, the attacker abandons any soft glove approach. He calls in artillery and air strikes on strongpoints and suspected strongpoints. The city is destroyed because the defense gave the attacker only two options: accept defeat or inflict destruction.

III.2 The City

From the analysis of past combat in built-up areas it became evident that in a high intensity conflict situation there is relatively little movement on the streets and that one of the most important battles becomes the seizure or defense of a building. At lower levels of combat intensity, however, the streets may not be deserted. For example, in the battle for Hue in 1968 civilians moved freely about the city and often avoided only the immediate battle zone. Even in high intensity conflict such as the urban operations that characterized World War II, it may sometimes become necessary to advance on the street as this is the only means available to dislodge a stubborn defender. As a rule of thumb, it may be stated with

confidence that the city defender moves on the streets far less than the opposing force that is attempting to dislodge him.

In either defense or offense it becomes necessary to fortify or attack certain buildings in a built-up area. A classification of city buildings of military interest includes:

- Steel-Concrete Buildings. These buildings are the most suitable for defense, being the least vulnerable buildings in a built-up area. Examples abound of the difficulty in assaulting these structures (for example the office buildings in Manila and the famous tractor factory in Stalingrad). The ceilings and exterior walls have a great resistance to blast and penetration. The basements in this type of building are suitable for conversion to covered positions for personnel, antitank (AT) bunkers, and storage of supplies. However, steel concrete buildings usually require more work to convert to defensive positions because of the numerous and large window openings and lightly constructed interior walls. This is particularly true of the more recently constructed buildings that emphasize glass sidings. Also, the central heating and air conditioning systems in modern office buildings conduct heat and smoke very rapidly through the building. Modern high rises, having essentially closed faces, act like dangerous giant chimneys, channeling heat and smoke rapidly up the interior.
- Brick and Natural Stone Buildings. These buildings are also suitable for defense. The strong walls of these larger buildings (schools, factories, apartment houses, and the like) can normally withstand strong bombardment. The cellars, however, do not always have the necessary strength to support the rubble should the building be destroyed. If the cellar is to be used, its ceiling should be reinforced with timbers.

- Half-timbered Buildings. Half-timbered buildings and buildings of wood are the least suitable for defense. Their method of construction and combustibility make them a constant danger to the defender. A conversion therefore is of little use. However, the cellars are suitable; they often have curved ceilings made of stone or even steel-concrete which can take the weight of rubble should the building be destroyed. This makes them particularly valuable as covered positions.

In preparing a building for defense, the materials used in the construction of the walls and ceilings are of particular importance. It is the characteristics of these which determine the extent of conversion that is necessary to make the structure relatively secure. If the walls and ceilings are constructed of a strong material, (for example, concrete), they are of great value for cover purposes. Cover, however, is minimal when light material is present (for example, hollow bricks). The type of material present should be determined before the building is converted to a defensive position. Under some circumstances either the plaster would have to be removed, or the wall might have to be broken up to determine the type of material used. Frequently, sandbags are placed behind walls to give increased protection.

An indication of frequency of construction types found in modern cities is shown in Figure 1. The numbers are of far less importance than the trend they reflect — the significant increase in those buildings most difficult to attack, especially reinforced concrete structures. This is particularly true for those cities either gutted in World War II or which have experienced high intensity combat since that time. There is a tendency over the world to use reinforced concrete where once wooden frame sufficed.

LAND USE	CONSTRUCTION TYPE						TOTAL
	WF	BR	ARC	JRC	HSF	LSF	
Downtown Business	2%	33	63	0	1	0	48
Suburban Business	10	52	34	0	3	0	4
Light Manufacturing	12	36	45	2	4	2	7
Heavy Manufacturing	21	26	42	2	8	2	12
Warehouses	10	43	36	1	6	3	4
High Apartment Buildings	7	35	58	0	0	C	5
Low Apartment Buildings	36	47	14	0	1	2	0
Large Residences	33	54	11	0	1	0	9
Small Residences	54	44	2	0	0	0	6
Blighted Residences	13	48	22	0	0	0	5
TOTAL	13	37	47	.56	2.22	.63	100

WF-Wood Framed
BR-Brick
ARC-American Reinforced Concrete
JRC-Japanese Reinforced Concrete
HSF-Heavy Steel Frame
LSF-Light Steel Frame

Figure 1. Typical Construction in Modern City

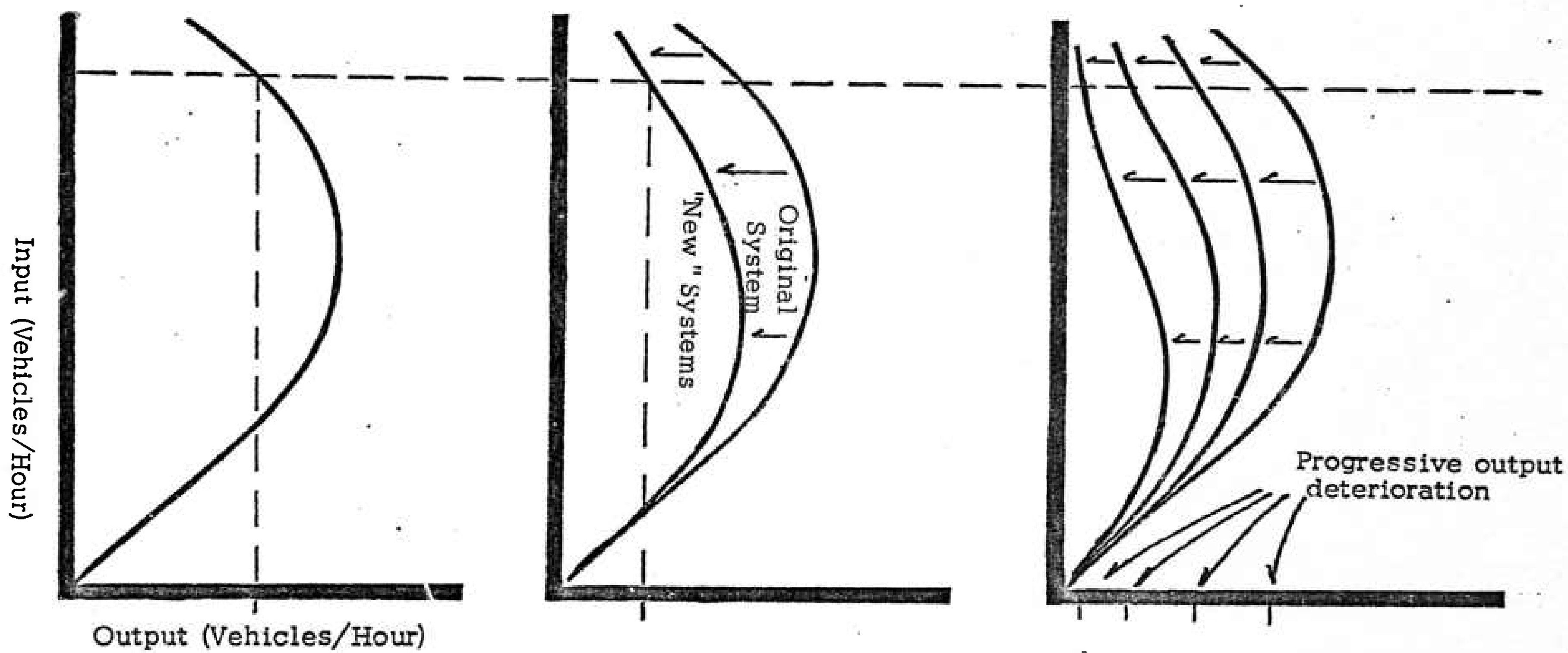
III.3 The Automobile

One of the most striking differences between the cities of the past and those of today is the large increase in the number of automobiles and other vehicles. Many modern countries have as much as one car per family. In these countries the onset of a military invasion will precipitate unprecedented civilian motor traffic. This could well result in massive, catastrophic road congestion as a vicious three phase cycle is encountered:

- Phase 1. Every road system has a response curve of the form shown in Figure 2(a). Very heavy refugee traffic would drive the system output flow to an unprecedented low. This would soon bring on Phase 2, Figure 2(b).
- Phase 2. Vehicle abandonment results from overheating, breakdowns, impatience, and fear (especially if artillery or aerial fires are observed). This brings on Phase 3.
- Phase 3. The abandoned cars create an essentially new road system with an inferior response so that the output flow is reduced even further. But the reduced flow exacerbates the Phase 2 abandonment problem which increases the Phase 3 system deterioration. The system rapidly grinds to a virtual halt, Figure 2(c).

In addition to the mobility problem caused by refugee vehicles, there are other tactical implications:

- Parked or abandoned vehicles create rich cover for troops moving in the street. The sheet metal and possibly even window glass could defeat small arms (for example, the M16) and many fragmenting munitions (for example, grenades, small mortars).
- Mines and boobytraps. The parked car is an ideal location for remotely detonated mines and boobytraps.



(a) Phase 1. System overload creates low output.

(b) Phase 2,3. Vehicle abandonment creates new system response.

(c) Total deterioration as cycle continues.

Figure 2. The Motcrized Refugee Problem

- Barricades. Commandeered autos can be used to build effective antivehicle and even antiarmor barricades.
- Other. Possibly the private vehicle will see even more imaginative uses, such as a mobile bomb for breaching buildings and barricades or as a contingency troop vehicle.

III.4 The Helicopter

Today's Army has one vehicle unavailable in the city battles of the great conventional wars — the helicopter. Only in the last years of Vietnam has the helicopter gunship been brought into urban warfare -- and with some tactical success. Airmobile operations have yet to be attempted in cities.

To more fully appreciate the potential of the helicopter in urban warfare, consider the following applications:

- Airmobile Assault. Doctrine for fighting in cities recommends clearing buildings from the top down when possible. This has rarely been possible. But the airmobile concept makes the doctrine viable. One can even envision a radical new doctrine of taking a city from the top down — starting with a sudden airmobile assault on the tallest buildings, from which covering fires would be supplied for subsequent attacks on lower buildings.
- Aerial Artillery. Conventional artillery loses much of its effectiveness in cities due to the extreme accuracy requirements. As an indirect fire weapon, artillery cannot hit a specific building on the first try. (Also, because of line-of-sight (LOS) considerations, the forward observer (FO) will often be very close to his target in the city; he is therefore in danger of calling down artillery on himself.) The FO is able to specify the target location very accurately, even to the exact window; yet artillery is incapable of comparable delivery

accuracy. The helicopter gunship, however, is capable of accurately delivering fire to a designated floor or even to a room.

- Covering Fire. The helicopter gunship should prove useful in covering either ground or airmobile assault on a building. In an airmobile assault on a building the gunship could prepare the roof for easy entry by blasting open the superstructure or breaching the roof itself.
- Other. There are numerous other potential areas of application, including patrol; bombing (low speed, high accuracy, with delayed detonation to allow safe separation); illumination; smoke laying; mine or gas dispersal.

Although the potential for use of helicopters has been recognized by others, there is yet to be analysis or experimentation to quantitatively estimate effectiveness or vulnerability. The subject is treated in more detail in Paragraph IV.4.

III.5 <u>Guided Munitions</u>

Recent and projected technological breakthroughs in guided munitions, such as laser guided weapons, offer major advances in firepower capability, particularly with respect to delivery accuracy and target selectivity. Although the unit cost of such systems is considerably higher than ordinary unguided munitions, they are still highly cost effective for some obvious (and some not-so-obvious) reasons:

- Higher probability of hit and kill, therefore, fewer munitions required to defeat threat
- Lower weapon carrier attrition due to longer standoff ranges (that is, increased helicopter survivability)
- Shorter time to kill, therefore, reduced exposure of friendly forces to the threat and less chance for enemy evasive maneuver

• Reduced collateral damage and noncombatant casualties

Analyses of combat experience in cities have shown that area saturation with conventional munitions (artillery or air delivered) has been generally ineffectual in quickening the advance and forcing the battle outcome. Strong points of resistance, selected by the defender for their relative invulnerability, tend to survive such general bombardment while the surrounding nonmilitary targets are reduced to rubble -- with, incidentally, a retarding effect on the mobility of the advancing forces. In contrast, it has been found (for example, Aachen, Hue) that direct, short-range, intense attack on the strong points has done more to advance the attack with fewer munitions expenditures and in shorter time. A penalty of this latter mode of operation is the higher initial casualty rate suffered by the attackers — although the final aggregate of casualties received over the duration may be lower. The application of laser guided weapons or other smart systems to attack such strong points may offer the advantage of achieving the firepower mission in the desired time while still minimizing casualty losses and collateral damage.

The accelerated development and application of laser guided weapons have led to authoritative predictions that by the late 1970s and early 1980s, availability will have increased to the point that each infantry platoon will include one hand-held laser designator (four per company). These studies, including "Snapshot 1" (Europe late 1970s) and "Wargame BEECH" (Marine Division/Air Wing amphibious assault), indicate that laser designators when coupled with appropriate command-control-communications networks will give the forward echelon ground troops (as well as elevated platforms) the ability to deliver highly accurate support fire upon selected targets with more localized terminal effects.

The role of the forward infantry elements, especially in urban environments where maneuver is severely constrained, can be seen to be growing further in the direction of becoming the eyes and ears of more

sophisticated support fire systems. Instead of the usual voice communications of the forward observer to locate targets and adjust fire, advanced systems are envisioned in which the target location will be pinpointed by a laser-rangefinder-designator and transmitted automatically (possibly in digital form). The observer would indicate the selected payload to match the target, and the fire direction center (FDC) — after diagnosing the threat array and surveying the disposition of weapon and munition assets — would select and instruct the appropriate smart weapon to respond.

Several consequences of this trend can be seen:

- The platoon organic firepower displaced by the laser device may have to be replaced by increasing the capabilities of the weapons remaining.
- Against a sophisticated enemy, the laser designator is a locatable signal source for counterfire or can trigger other responses such as evasive maneuver; therefore, the elapsed time from target detection through C^3 to payload impact should be minimized. Also in this regard, the concept of a beacon munition that could be delivered onto the target by a weapon organic to the platoon or company should be considered. The beacon, a radiation source (perhaps pyrotechnic or radio), would be implanted ballistically on the target — with minimum signature and exposure of the operator — and would serve as the homing signal source for munition delivery by artillery or air or missile.
- One means to reduce response time is to consider close support launch systems for smart munitions (or even launch systems organic to the forward ground elements) so that trajectory time is reduced as well as C^3 time. For example, this capability might be provided for the 4.2 in mortar by a

special munition equipped for terminal homing on an implanted beacon or a laser designated target. Perhaps the 106 mm RR could be similarly equipped for helicopter gunship armaments or tactical air support systems.

This subject is discussed in greater detail in Paragraph IV.3.

III.6 Lessons of History

The history of urban combat doctrine, tactics, weapons, and targets over the past thirty years was discussed in previous technical reports. At this time the most important implications and requirements will be discussed.

City combat has historically been marked by vicious close combat and point-blank artillery fire. Largely due to the severe line-of-sight restrictions, short range engagements will continue to be prevalent in urban combat. Weapons for interior fighting are particularly important. The submachine gun has been very good in this role in the past due to its short length and high lethality. Small arms fire through interior partitions was important in the past and should continue to be important in the future.

Grenades have been a primary armament for infantry combat in cities. At Cassino, for example, battalions used 500 grenades per day. Concussion grenades were particularly useful in World War II, as attested by after action reports from the European theatre. Such grenades are particularly potent in enclosed areas such as rooms or subterranean passages.

Sniper teams have been outstandingly effective in city defense. In Warsaw (1944) and Stalingrad, for instance, the Germans suffered some of their heaviest losses from sniper fire. By operating in teams, snipers provided for mutual support and the staging of ambushes. In city combat the ideal sniper weapon is short, silenced (or at least suppressed), and accurate.

Conventional indirect artillery fire and tactical air bombardments have proven to be of arguable value in city attack since they seldom defeat defensive strongpoints and cause the production of rubble which impedes the attacker's thrust. Because they select well protected positions, few enemy soldiers are killed by such fire; collateral damage and civilian casualties are produced instead. On the other hand, direct point-blank artillery fire has been extremely important in reducing enemy strongpoints and breaching buildings. This is why tanks and self-propelled (SP) artillery have been successful when brought into cities despite doctrine to the contrary. Larger caliber fire is capable of quickly destroying an enemy weapon emplacement before it can be displaced, an all too easy maneuver in the city environment.

Tanks have faced a particularly knotty problem in cities — what types of round to carry in the chamber. The high explosive antitank (HEAT) round is ineffective against weapon emplacements. It simply tends to punch small holes without major lateral effect. The high explosive (HE) round is fairly effective against such emplacements but is ineffective against enemy tanks. A compromise round might be high explosive plastic (HEP) which is effective against both threats, although it is susceptable to passive tank defenses such as skirting armor.

The severe geometry of the city with its numerous corners make weapons that can turn corners very attractive. The Germans devised a rifle with a curved barrel and a machine gun with a periscopic sight, although these apparently saw limited use. At least one such curve weapon is under current consideration, namely, the magnus-lift grenade. The utility of such a grenade or other boomerang weapon is illustrated in Figure 3 which indicates a battle that took place in the Warsaw uprising. The curved trajectories show how the Poles could have used such a curve weapon. It is recognized that accurate delivery of a curve munition requires an accurate knowledge of target location and a precise, reproducible trajectory — both difficult to achieve in practice.

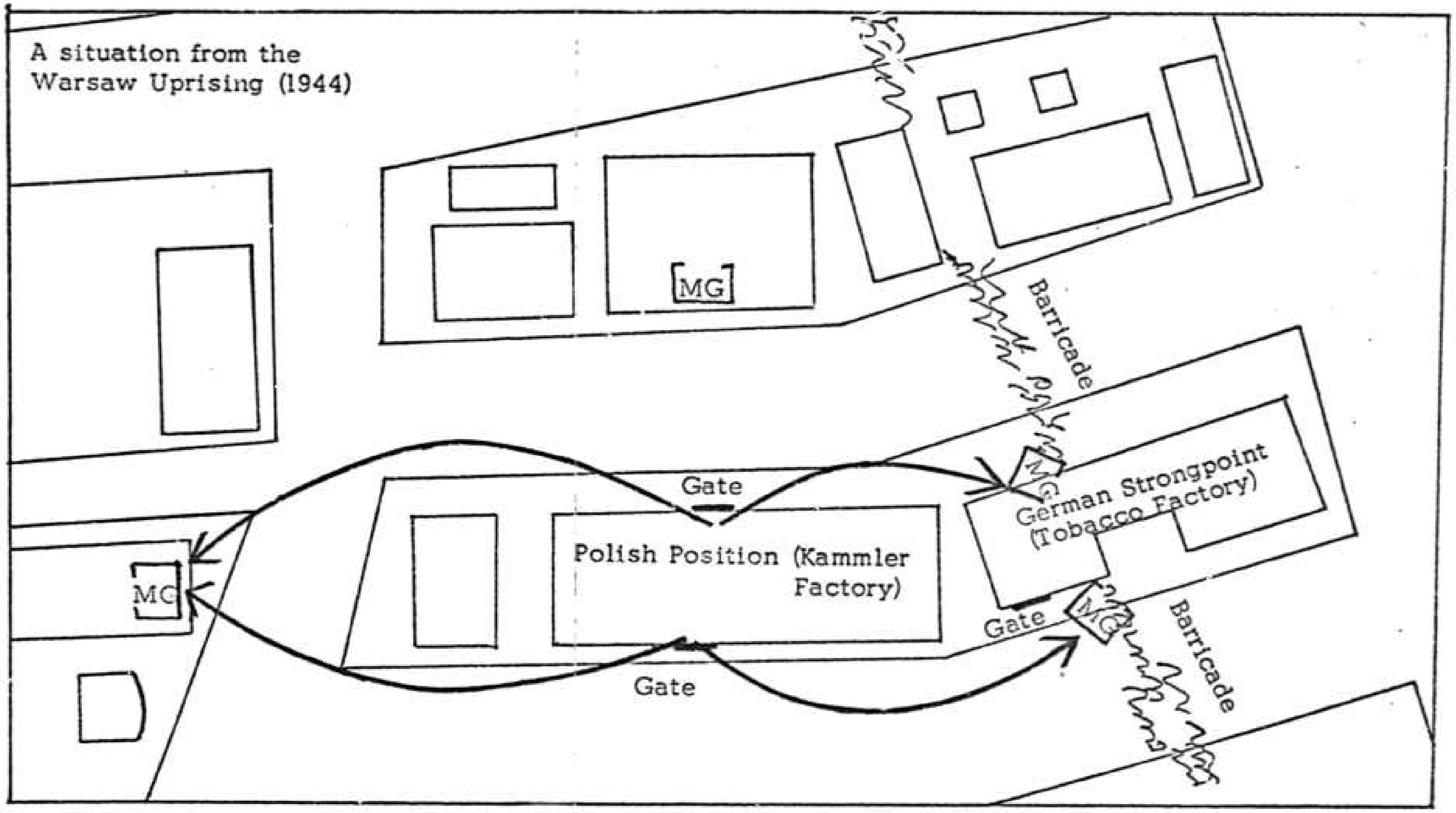


Figure 3. An Example of the Potential Use of "Curve" Weapons in Urban Combat

III.7 Doctrinal Analysis

For an attacker the urban environment represents strongpoint enemy positions where structures and facilities afford the defenders with advantages in fields of fire, concealment, protection, mobility, and communication seldom available in the natural environment. The degree to which these advantages are present is generally scaled to the size and technological development level of the built-up area considered. Probably the greatest example of the advantages exploited by the city defender is in the Russian Sixty-second Army's successful defense of Stalingrad against massive and prolonged application of military force during World War II.

Because of the significant advantages accruing to the defender, conventional military doctrine generally prescribes that land combat forces should by-pass built-up areas whenever possible. This is desirable to avoid loss of time, momentum, and personnel -- as well as unnecessary damage to the built-up area itself. Avoidance is not always feasible, particularly when the enemy chooses to fight in or otherwise utilize the city to support his operations. Further, many areas where fighting is likely to take place are becoming increasingly urban. The sprawling suburbs and contiguously located small communities will continue to make the doctrine of "by-pass and isolate" less tenable.

As a consequence of the basic nature of intensive combat in a built-up environment, U.S. Army doctrine for attack in this environment recognizes the high hazards faced by the attackers and prescribes a full use of heavy firepower both to approach and to root out the defenders. Typically prescribed tactics call for full use of armor, including armored personnel carriers, to move troops forward and recommend the placement of recoilless rifles, bazookas, heavy machine guns, and even mortars in the leading edge of the attacking force. Heavy use of night cover for maneuver in advance is recommended. Using these tactics, buildings and facilities are targets for rapid and intensive reduction wherever and whenever they afford significant advantage to the defenders.

The use of larger weapons in the leading edge of the assault is in sharp distinction to the Soviet doctrine. The Soviet tactic is to enter the city outskirts with less firepower, hoping to gain the advantages of continued forward movement through by-passing strong points. The by-passed areas are later reduced by second echelon units equipped with larger weapons; these units are also on call to the infantry-tank teams that compose the forward edge of the assault. Schematic summaries of the U.S. and U.S.S.R. doctrines are shown in Figure 4.

This chart represents prescribed doctrine -- what is supposed to be carried out -- not necessarily what has taken place historically. The Soviet assault doctrine for built-up areas places less emphasis on consolidation of achieved objectives than the U.S. doctrine. American emphasis on completely clearing areas that are to be encompassed is made explicit in Field Manual FM 31-50: "To by-pass buildings would be to risk being attacked from the rear. It is necessary to enter and search each building during the progress of the attack." Whereas some Soviet generals freely admit the impossibility of protecting flanks during street fighting, the American doctrine is that the flanks can be protected by a combination of large amounts of firepower, a methodical house-to-house clearing of large urban areas, and a consolidation of achieved objectives.

On a much lower scale the flowcharting of doctrine can also be a useful tool in analyzing some seemingly small differences in tactics -- such as methods of entering a room possibly concealing an enemy (Figure 5) -- and assist in the synthesis of new tactical approaches and novel concepts of materiel and doctrine.

At an intermediate level the flow chart (Figure 6) is used to depict combat actions utilizing several small groups of infantrymen. For example, the Soviet doctrine for the assault of a fortified building is

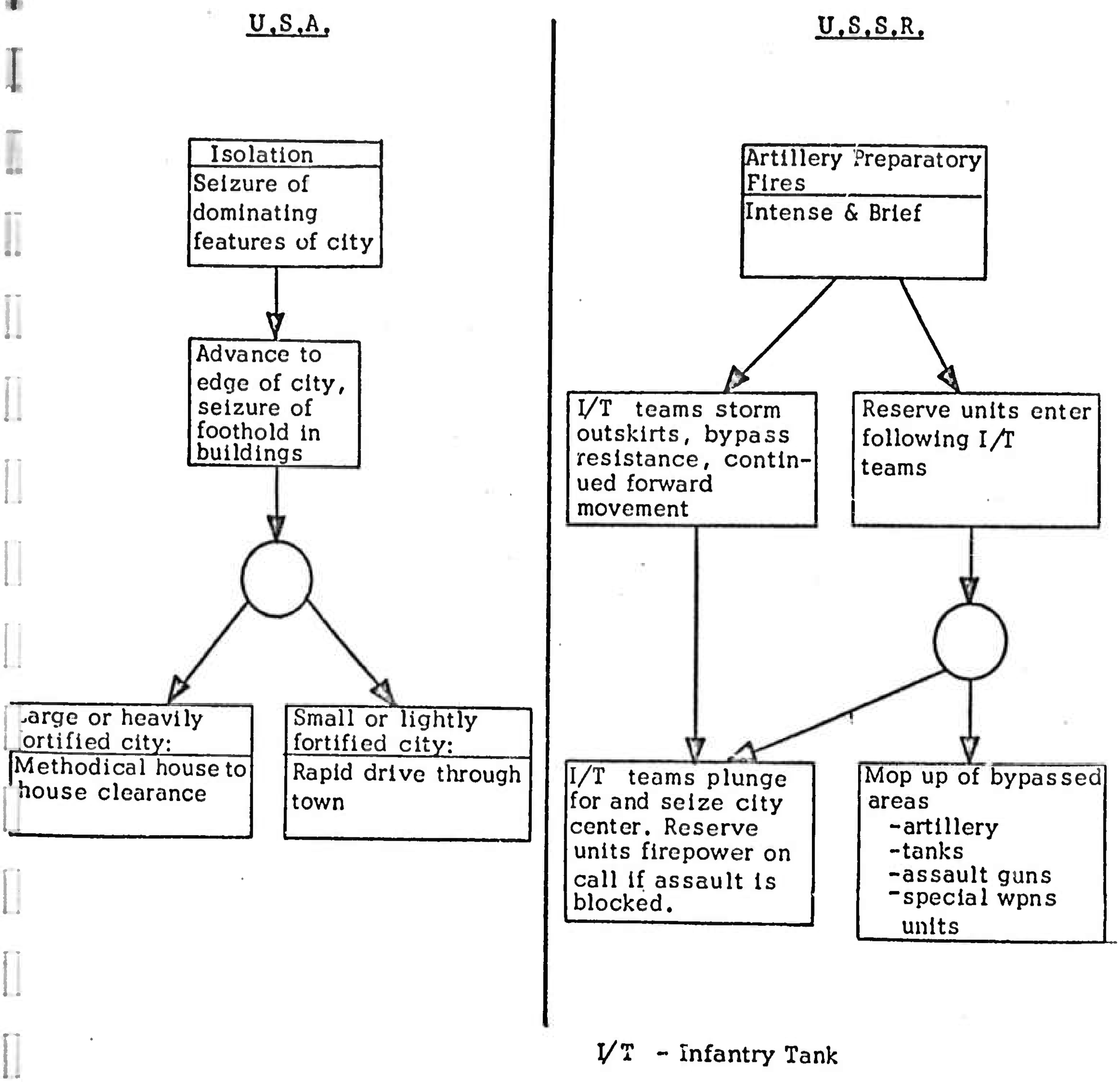


Figure 4. The Attack of a Built-Up Area: Comparative Doctrines

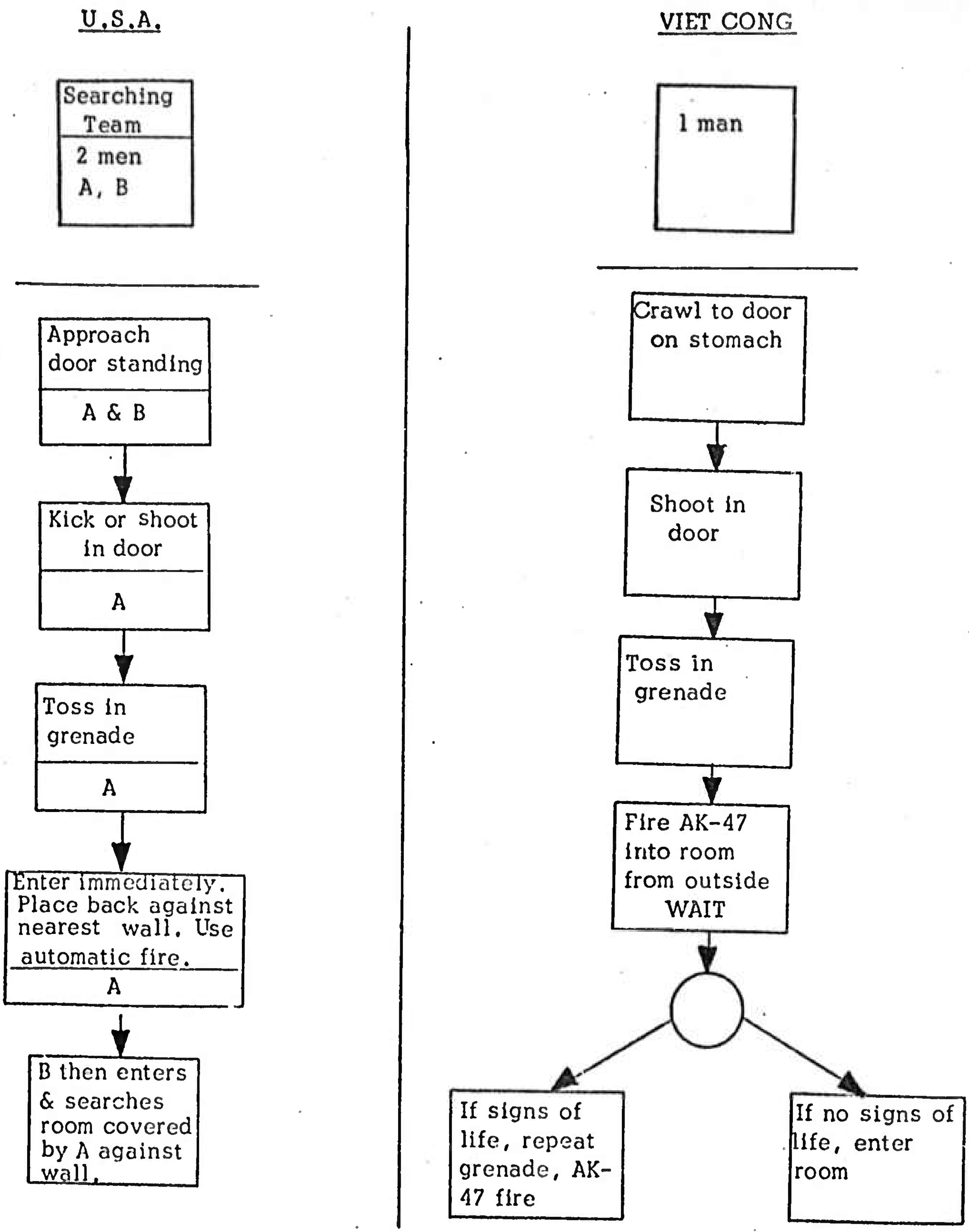
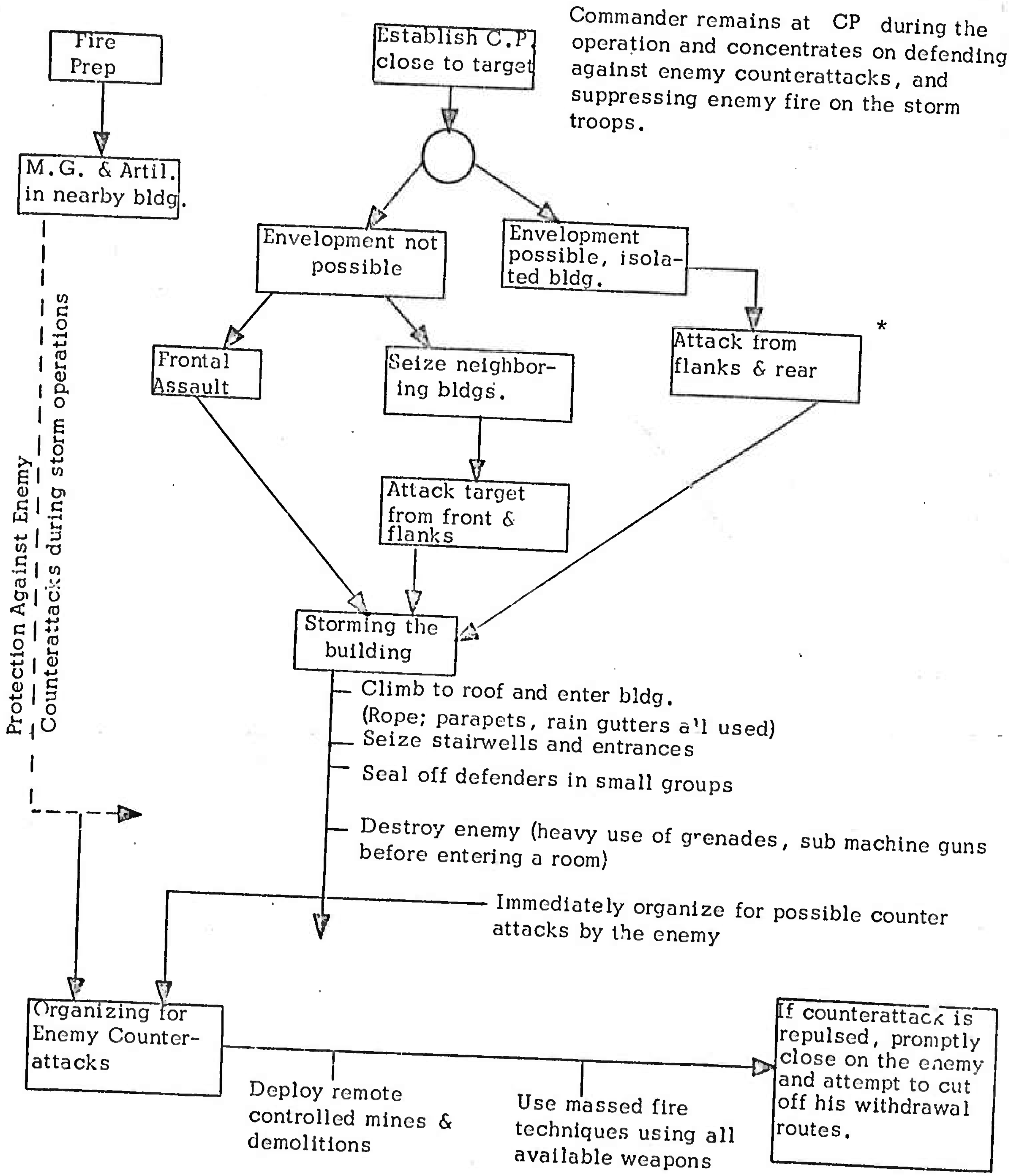


Figure 5. Entering a Room: Comparative Doctrines

relatively detailed in terms of what actions must be executed and in what order they are to be carried out. For such an assault there is a breakdown of force into specialized small units, paralleling the Soviet belief that street fighting is essentially a small unit combat action (Figure 7). The comparison of Figure 6 with the prescribed U.S. doctrine stated in Field Manual FM 31-50 for the attack of a building shows the differences in both emphasis and method. Once inside a building, the Soviets attempt to seize the stairs; thus separating defenders into small groups that can be destroyed one by one. In contrast to this, the U.S. doctrine advocates a floor by floor clearing of the building, again showing the U.S. emphasis on refusing to by-pass potentially threatening centers of resistance. Here, too, the Soviets proceed in a building with unprotected flanks in full compliance with their method of assaulting a city (that is, with small unprotected units engaging in an initial thrust to achieve a real or symbolic objective). In fact, the Soviet doctrine generally relies on infiltration and surprise as opposed to a doctrine of firepower in massive concentrations. Marshal Vasili Chuikov, commander of all Soviet land forces in the mid 1960s and also a commander at Stalingrad and Berlin, asserts that the danger that the enemy will pinch off exposed flanks is only imaginary since the confusion of battle and the difficulties in command and control will not allow the enemy to exploit this weakness. It should be pointed out that this method of street fighting was developed by the stimulating experience of Leningrad, Moscow, Smolensk, Stalingrad, Kiev, Berlin, and Budapest.

U.S. doctrine, again in contrast to Soviet methods, calls for isolation of built-up areas, at least to the point where an assault may be launched from a safe area into the city. Heavy firepower is then used prior to entering the edge of the built-up area. If accounts from Vietnam are correct, the amount of fire delivered before entrance into a city has increased from the amounts delivered on Aachen and the cities in the Ruhr pocket.



* Rear assaults place heavy emphasis on using underground methods of attack e.g. subways, tunnels, etc.

Figure 6. Deliberate Attack of Strong Points

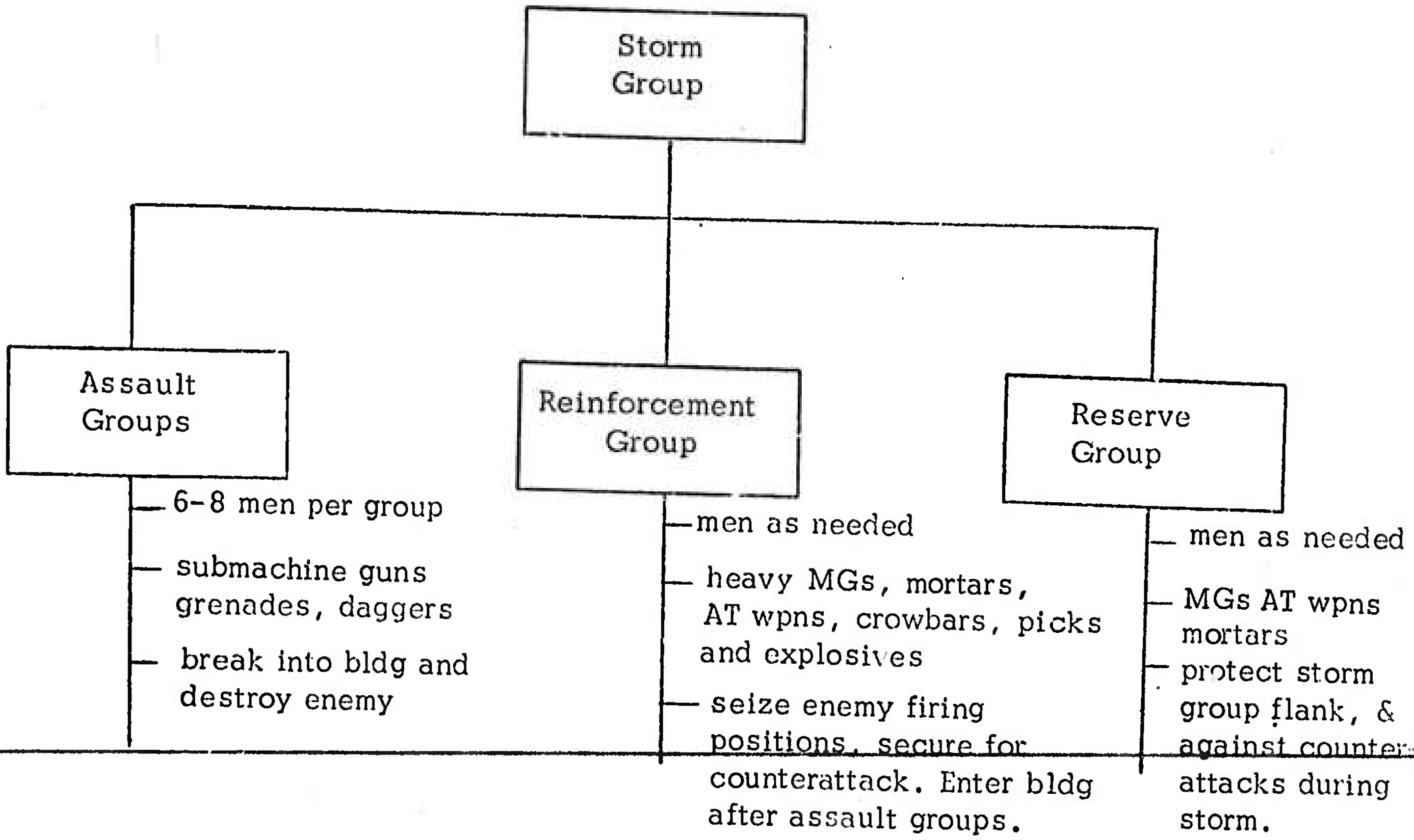


Figure 7. Soviet Units for Attacking Fortified Buildings

As far as U.S. experience is concerned, the actual movement in the city itself during a street fighting situation is seldom on the streets. Reliance is often placed on house-to-house methods of advance in which forward elements systematically blow holes from one building to the next. The method chosen to initiate an attack on a city is naturally dependent on constraints such as time, enemy strength, and other considerations. The variations of strategy demonstrated from twentieth century experience are considerable. Of these variations six may be singled out from a tactical standpoint as representing the range of attacks on urban areas. These six cases are sketched in Figures 8, 9, and 10. All of these cases deal with general war situations, even though the assault on Warsaw was waged against guerilla type forces who held out for sixty-three days against an overwhelming German advantage in firepower. Although the foundations of the modern phenomenon of urban guerilla warfare were laid at Warsaw, the standard for street fighting ferocity and the development of small unit tactics in built-up areas clearly stems from the Battle of Stalingrad. Stalingrad is an example of the dominance of tactics over hardware and demonstrates that improvement in tactical concepts may be more beneficial than improvements in weaponry.

III.8 Vulnerability Considerations

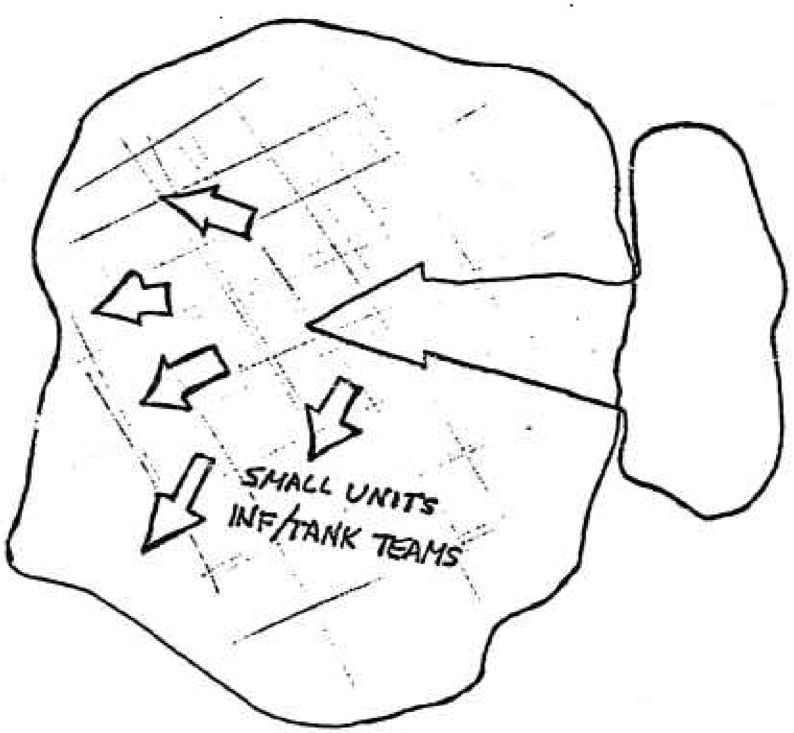
In carrying out firepower missions in the urban environment when high priority is placed on minimizing collateral damage and non-combatant casualties, the tactical context and total target structure faced by the attacker differ radically from those faced in usual field operations. This divergence is particularly sharp in situation involving insurgency units because both the civilian population and the city structure are high priority elements to be preserved while carrying out neutralization or destruction operations against the hostile forces.

In this situation the enemy forces are a priori targets for weapon effects while the noncombatants and material structures are potential but

CITY ASSAULT TACTICS

SOVIET DOCTRINE

e.g. BERLIN



U.S. DOCTRINE

e.g. AACHEN

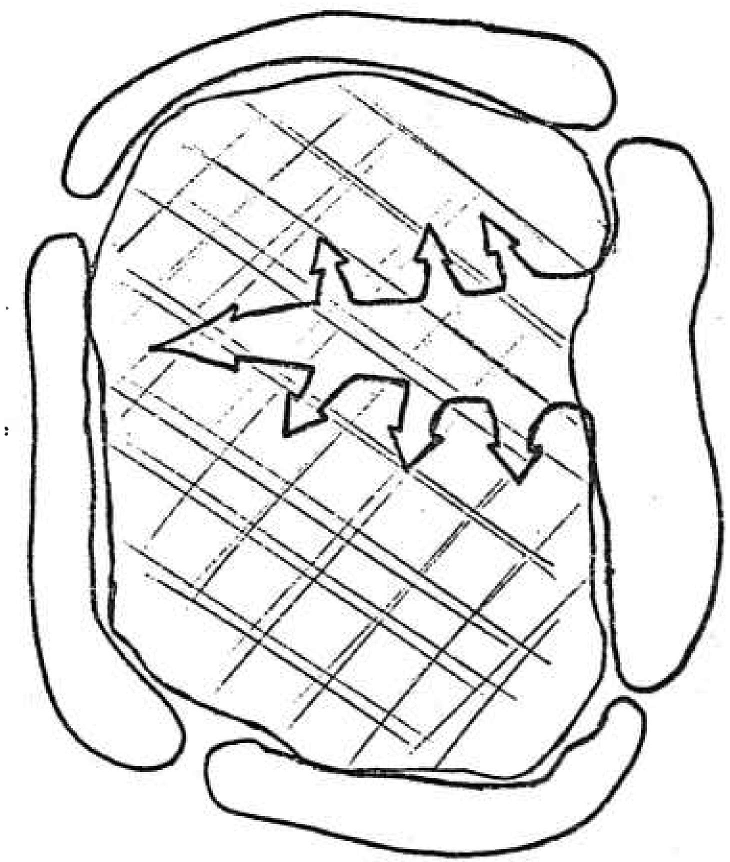
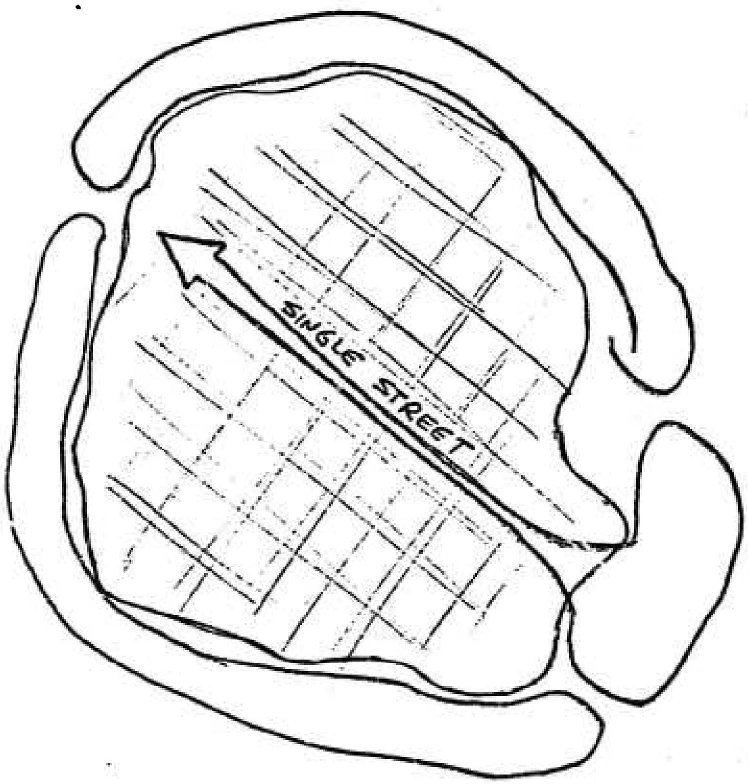


Figure 8.

CITY ASSAULT TACTICS

GERMAN ASSAULT
MASSIVE CONCENTRATION
WARSAW '44



GERMAN ASSAULT ON
STALINGRAD '42

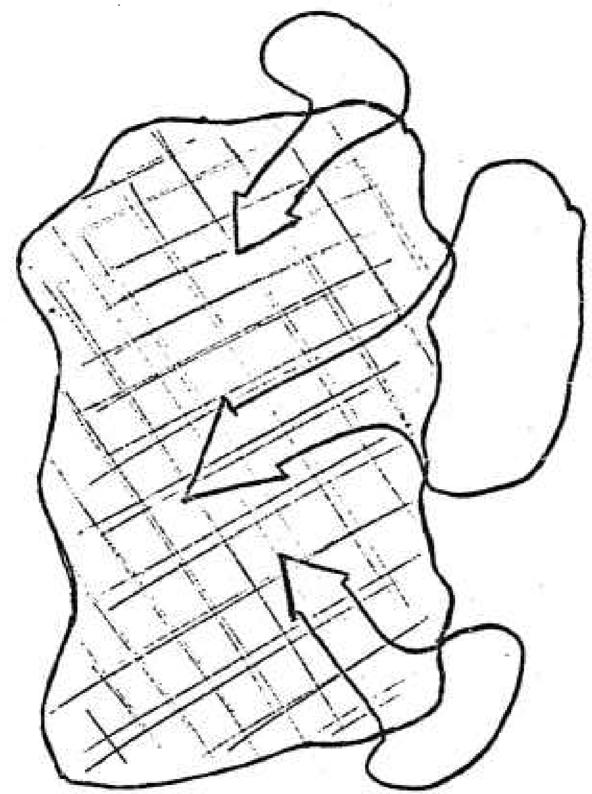


Figure 9.

CITY ASSAULT TACTICS

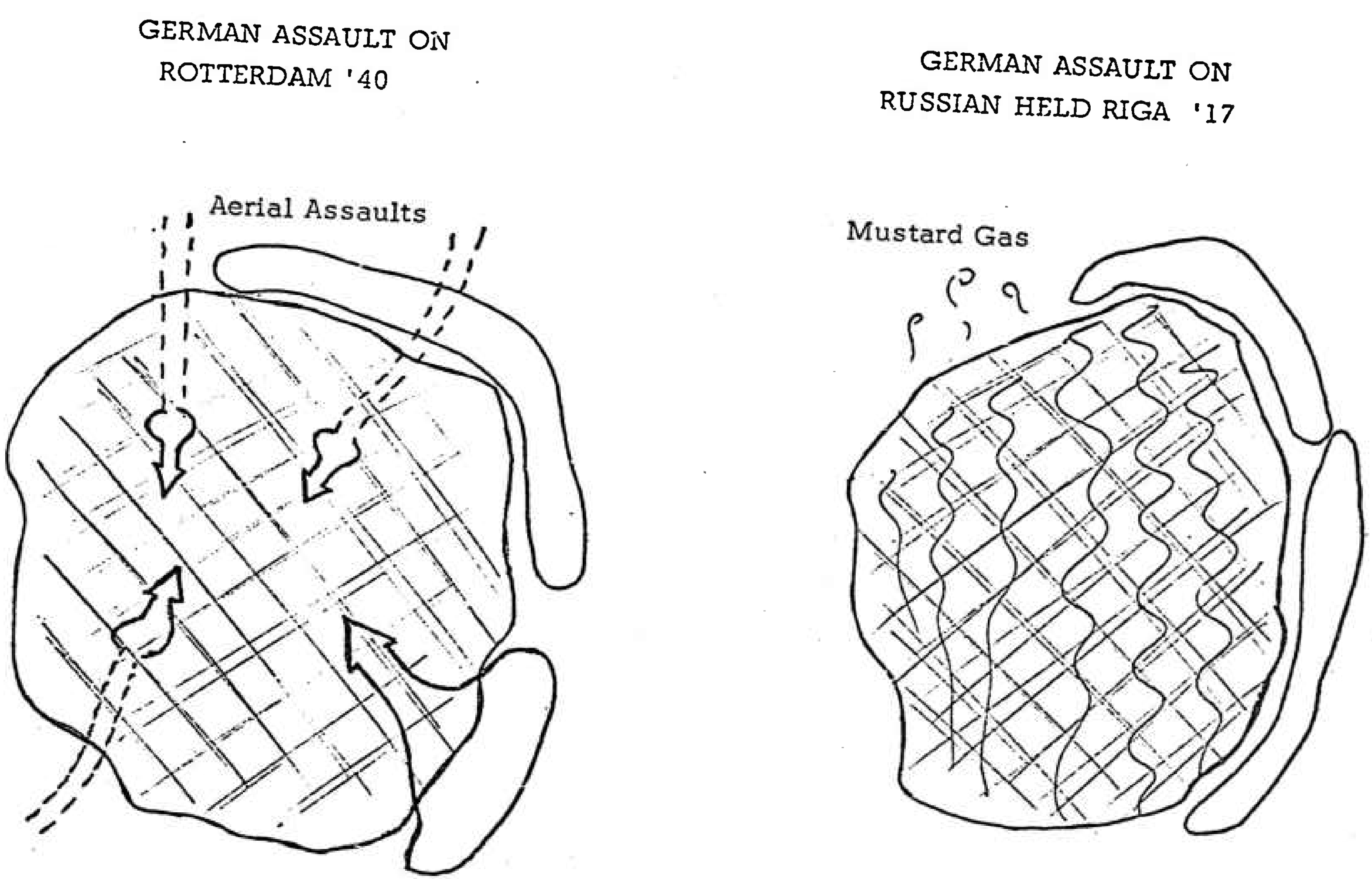


Figure 10.

inadvertent targets. The degree to which this target role is inadvertently imposed on noncombatants and material structures will be dependent largely upon the inherent effectiveness and controllability of the attacker's weapons and the magnitude of collateral destruction acceptable as a matter of policy.

Broadly, this composite target structure can be broken down into the following principal elements:

- Human
  - Combatants
    - U.S.
    - Friendly
    - Hostile
  - Noncombatants
- Structures
  - Residential
  - Product processing
  - Public
- Utilities
  - Electricity
  - Water
  - Gas
  - Telephone
  - Sewage
  - Streets
- Transport
  - Cart/rickshaw
  - 2-4 wheel personal
  - Buses/trucks
  - Trains/trolleys
- Life Support Systems
  - Firefighting
  - Medical
  - Food warehouses
  - Reservoirs
- Consumable Supplies
  - Food
  - Clothing
  - Drugs
  - Fossil Fuels
  - Water

While this breakdown is far from exhaustive, it is sufficiently broad to permit an assessment of the relative merits of weapon systems that are candidates for employment in the urban environment.

If, initially, considerations are limited to the small arms present in today's U.S. forces, there are only three energy transfer damage mechanisms available for application against the target structure. These are kinetic energy projectiles (bullets and warhead fragments), blast

pressures, and thermal generators. When the basic target structure list is combined with these damage mechanisms as shown in Table 1, it is immediately apparent that the analysis of target vulnerability can involve a major data matrix that can expand to almost any size depending on the degree of infrastructure examined.

For purposes of the present study that level of data acquisition and analysis that permits basic relationships to be identified and relative target effectiveness to be compared without overloading the program resources or obscuring the critical interrelationships will be pursued.

III.9 Functional Area Interface

Firepower may interact postively or negatively with the other combat functional areas. Complementation is particularly important and must be kept in mind lest important weapon systems be overlooked. In Table 2, areas of complementation are summarized. Some of these areas are particularly problematic and have been so indicated. Other areas have not been well explored and are fertile ground for innovation and improvement. Areas of discord are summarized in Table 3.

Another useful approach to analyzing the interaction of firepower with the other functional areas is to investigate each weapon phenomenon individually and explore its interaction with the other functional areas. This is done in Table 4.

III.9.1 Firepower and Mobility

Firepower can assist Mobility by clearing routes, removing obstructions, and suppressing hostile fire. In the urban environment traffic congestion will be an extremely serious problem for the defender, especially in modern countries. The initiation of hostilities may be expected to precipitate a mass exodus resulting in massive vehicular and pedestrian congestion that seriously impedes troop movement. Firepower can aid in clearing routes through such congestion by the use of repulsive agents ranging from annoying sound through nontoxic gases on up to lethal weapons.

Table I. Target Vulnerability to Fire from Standard U.S. Small Arms

Target \ Weapon Damage Mechanism	M16			M60			M79			M20A			M40A		
	P	B	T	P	B	T	P	B	T	P	B	T	P	B	T
Personnel															
Exposed	H	.	.	H	.	.	M	L	.	VH	M	.	VH	M	.
Protected	L	.	.	M	.	.	VL	VL	.	H	L	.	M	L	.
Building															
Native Hut	VL	.	.	L	.	L	.	M	L	M	H	M	M	VH	M
Frame	VL	.	.	L	.	L	.	M	L	M	H	M	M	VH	M
Metal	.	.	.	VL	.	.	.	L	.	M	M	.	L	H	.
Stone/concrete	.	.	.	.	.	.	.	VL	.	M	L	.	L	M	.
Steel Frame Multifloor	.	.	.	.	.	.	.	VL	.	M	L	.	VL	M	.
Utilities															
Electric	VL	.	.	VL	.	.	VL	VL	.	VL	VL	.	VL	L	.
Water	M	.	.	M	.	.	VL	VL	.	VL	VL	.	VL	L	.
Sewage	VL	.	.	VL	.	.	VL	VL	.	VL	VL	.	VL	L	.
Telephone	VL	.	.	VL	.	.	VL	VL	.	VL	VL	.	VL	L	.
Elevator	L	.	.	L	.	.	L	M	.	M	M	.	M	H	.
Street	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Transport															
Cart/Ricshaw	M	.	.	H	.	.	VL	H	M	H	H	M	M	H	H
Automobile	L	.	L	M	.	L	VL	M	M	H	H	M	M	H	H
Bus/Truck/Trolleys	VL	.	.	L	.	L	VL	M	M	H	H	M	H	H	M
Train/Subway	.	.	.	VL	.	.	VL	L	VL	M	M	VL	VL	M	VL
Life Support Systems															
Firefighting															
Medical Services															
Food Warehouses															
Reservoirs															
Consumable Supplies															
Food	.	.	.	.	.	VL	.	VL	L	.	VL	L	.	VL	L
Clothing	.	.	.	.	.	VL	.	VL	L	.	VL	L	.	VL	L
Fossil Fuel	L	.	.	M	.	M	VL	L	M	M	M	M	M	H	M

Damage Mechanism
P-Projectile, Fragment
B-Blast Pressure

Target Vulnerability
VH-Very High; H-High; M-Medium; L-Low; VL-Very Low; N-None

Table 2. Complementation Between Functional Areas

Other Function	Benefits Accruing: To Firepower	Benefits Accruing: From Firepower
Mobility	. Move weapon platforms	. Remove obstacles including indigenous traffic . Force detonate minefields* . Provide covering fire
Surveillance	. Locate troop concentrations . Locate weapons (especially by trajectory analysis) . Locate individual vehicles . Locate individual soldiers and especially snipers** . Provide postfire assessment	. Reconnaissance by fire . Battlefield illumination . Deliver sensors* . Respond to sensors without destroying sensors*
Communications	. Links with observers	. Provide high-altitude relay* balloons or parachutes . Deliver flare, smoke and other signals or markings . Deliver communications lines
Civil Interaction	. Remove noncombatants from firezones . Instruct noncombatants in protective measures . Provide weapon energy sources from utilities (gas, electric, water)	. Graded lethality weapons* . Weapons to minimize collateral damage

* Items have not been adequately explored.

** Particularly problematic.

Table 3. Discord Between Functional Areas

Other Function	Detriments Accruing: To Firepower	Detriments Accruing: From Firepower
Mobility	• Weight Limitation • Recoil Limitation • Stability Limitation	• Route damage (e.g., cratering, bridge destruction) • Route blockage (e.g.,rubble) • Interference with operators (e.g., by wounding, frightening, overcoming by chemicals) • Damage to vehicles
Surveillance	• Electromagnetic noise interfering with fire control • Restriction of sensor damage (including forward observers)	• Obscuration (smoke, dust) • Noise (audio) • Electromagnetic noise (e.g., flash interference with night observation equipment, fire control radar interference with surveillance radar) • Interference with operators • Damage to equipment
Communications	• Electromagnetic noise interfering with fire control • Restrictions of damage to communications lines	• Noise (audio) • Electromagnetic noise (e.g., fire control radar) • Destruction of equipment (e.g., phone lines) • Interference with operators
Civil Interaction	• Restriction of injury to neutral populace and damage to resources	• Wounding, frightening, alienating populace • Destruction of resources

Table 4. Weapon Phenomena and Interaction with other Combat Functional Areas

Weapon Phenomenon	Functional Area: Mobility	Surveillance	Communications	Civil Interaction
Blast & Sound	. Rubble obstruction . Cratering . Interference with operators . Vehicle and crew damage	. Destruction of sensors . Triggering of seismic and audio sensors . Vibration of equipment . Signature of enemy weapons . Interference with operators	. Destruction of equipment (e.g., phone lines) . Vibration of Equipment . Interference with operators (especially hearing)	. Direct and indirect wounding including ear damage . Interference with hearing . Provocation . Damage to resources
Chemical agents (nonlethal, e.g., tear, CS, dye-marker, chemiluminescent)	. Interference with operators . Route marking	. Interference with operators	. Interference with operators	. Repulsion . Provocation
Communications band radiation (proximity fuzes)			. Interference with signals	
Flame or Heat	. Vehicle or fuel ignition . Interference with operators . Soft macadam	. Optical interference (including mirages)		. Wounding . Repulsion . Provocation . Damage to resources

Table 4. Continued

Weapon Phenomenon	Mobility	Surveillance	Communications	Civil Interaction
Fragmentation	. Vehicle and crew damage	. Equipment and operator damage . Use of pattern symmetry to determine munition trajectory	. Equipment and operator damage	. Wounding . Provocation . Damage to resources
Magnetic fluctuations (from munition motion, explosion)		. Interference with magnetic sensors . Use to determine trajectory		
Optical and IR radiation (munition explosion, muzzle flash, laser devices)		. Interference with night observation equipment . Battlefield illumination . Use to locate enemy weapons		
Projectile flight		. Interference with doppler radars . Use to locate enemy weapons (doppler radar or audio sensors)		
Smell		. Use to locate enemy munitions (powder sniffer)		. Repulsion (stench bomb)
Smoke and Dust	. Interference with operator vision, respiration	. Interference with operator vision, respiration . Radar, optical, IR interference	. Interference with operator vision, respiration	. Interference with vision, respiration . Obscuration of noncombatants

Vehicles moving through a hostile urban area are extremely vulnerable to Molotov cocktails, sniper fire, and antiarmor weapons. Firepower could assist the transit of such areas by providing effective suppressive fire or obscuring vision. Standard weapons do not fill this role satisfactorily. To list a few ideas for solving this problem: obscuration gases which cling to surfaces to a depth of a couple of feet thus obscuring firing ports but leaving adequate driver vision; a "splinter hurricane" to shower all buildings with a flux of sublethal splinters; a device to provide pulsed flashes of blinding light along the route together with driver goggles which black out during the pulse.

The vehicle moving through hostile territory must contend with barricades and mines. Firepower can aid the removal of barricades by demolition. It might also be feasible to design firepower devices to force detonate mines and booby traps.

Firepower impedes Mobility by cratering roads, creating rubble, and, when used in close proximity, threatening the vehicles and operators. These impediments will probably not occur with great frequency or magnitude in the scenarios we are presently considering.

Mobility aids Firepower by moving it to where it is needed and by removing it from hostile fire. This latter function will become more important with increased sophistication of countermortar radars. Mobility frequently has the additional function of providing a stable platform from which to deliver fires. In the urban environment there are many novel opportunities to apply this function. For instance, most major cities have navigable waterways within or nearby. These waterways are attractive as firepower positions; they offer significant freedom of movement, command critical avenues of approach, are level, and are relatively clear of indigenous population and structures. The defender might therefore find considerable merit in barge mounted artillery or mortars. A submarine artillery or rocket platform would enjoy considerable cover and concealment from the water.

By moving frequently, submarine platforms could avoid radar directed counterbattery fire.

An area of great potential in the Firepower/Mobility interface is the development of robot and remote control weapons. Weapons of this type could significantly reduce friendly casualties in interior fighting.

III.9.2 Firepower and Surveillance

Firepower can aid Surveillance by providing battlefield illumination, reconnaissance by fire, and by delivering sensors. The first two functions are well documented and will not be discussed further here. The third function is new and actually usurps a mobility function. Artillery is a cheap, safe, swift, and accurate method of delivering materiel to enemy territory. Artillery shells might be used to deliver button bomblets, radioactive tracer agents, chemiluminescent markers, or more sophisticated sensors. Such equipment must, of course, be designed to withstand the launch and impact environments.

Firepower interferes with Surveillance by creating noise (used here in the larger sense to include electromagnetic interference and the clutter of smoke, dust, and speeding objects). It further can interfere by actual damage to equipment and personnel. Insofar as these effects are for the most part unavoidable, Surveillance must grin and bear it or else establish constraints on weapon usage.

Surveillance is all-important to Firepower, being its eyes and ears. The accuracy and timeliness with which Surveillance provides information on the enemy (and on the indigenous population and structure) determines appropriate weapon characteristics. If a sniper location can be determined to an accuracy of a few cubic meters and relayed within a few seconds, an accurate direct fire weapon would be highly effective; if the location can be supplied only to within a building or only after several minutes, then the use of chemicals or search party becomes more appropriate.

In the urban environment Firepower requires strict discrimination among enemy, friendly, and neutral personnel, and good knowledge of the indigenous structures. When such discrimination is not possible, the uncertainty should be acknowledged and the consequences of alternative actions estimated.

To indicate the type of weapon system which could emerge from an outstanding Surveillance solution, consider an antisniper weapon. Suppose, for example, Surveillance were able to design a doppler radar which would yield a precise trajectory analysis of any incoming munition, then trace back along this trajectory to its intersection with a building. This intersection is the firing point. Such information, if available within a fraction of a second, could be fed to an integral weapon to immediately take aim and return the fire. A high velocity weapon firing a "slenderized grenade" would be particularly useful.

The development of remote, active barrier systems which detect and stop violators is an area which should receive considerable attention.

Surveillance can interfere with Firepower by positioning vulnerable personnel and materiel in areas of desired firepower application.

III.9.3 Firepower and Communications

Traditionally, Firepower has done little for Communications. Its use has been restricted to the delivery of flares, smoke, and other signals and markings. In an urban environment Firepower can prove more helpful. For example, because of line-of-sight restrictions, radio communication in a city is going to be very difficult. Artillery can provide assistance by placing high altitude relay stations above the city. These relay stations would be supported by parachutes or balloons to extend their useful life. High energy acoustic transmitters are being considered as graded lethality weapons; these transmitters could obviously relay information.

On the other hand, Firepower can interfere with Communications by noise (again in the larger sense) and by destruction of equipment

(especially communication lines). Such effects are for the most part unavoidable and Firepower can do little else than make Communication cognizant of the effects and their magnitude.

Communication links Firepower with Surveillance and command and control. Communications determines the timeliness of target reports, and that is crucial to Firepower effectiveness.

III.9.4 Firepower and Civil Interaction

Firepower can assist Civil Interaction by providing graded lethality devices for coercing the indigenous population. There will be many occasions when there is no time to persuade or cajole the populace to certain behavior, even in their own good. In these situations coercion is proper and necessary.

Civil Interaction can aid Firepower by removing noncombatants from fire zones and instructing them in protective measures. Further, Civil Interaction can provide Firepower with indigenous energy sources. The city is a repository for vast amounts of energy; Firepower is largely directed energy.

Civil Interaction interferes with Firepower by the imposition of constraints on collateral damage.

III.10 Findings and Recommendations Related to Historical Experience

FINDINGS	RECOMMENDATIONS
(1) Conventional airborne firepower has had limited tactical support value due to close quarters of urban combat operations and due to vulnerability of hovering and lowspeed aircraft.	(1) Doctrine, tactics, and weapons for use by helicopters in an urban environment show promising potential and should be developed in greater detail by Army and Marine Corps concepts agencies.
(2) Direct short-range fire by tanks and large caliber SP and towed artillery has played an important role in most offensive and some defensive operations.	(2) Doctrine for using direct short-range tank and artillery fire and materiel modifications to improve their survivability in built-up areas should be developed further by appropriate Army and Marine Corps agencies.
(3) The effects of indiscriminate indirect artillery fire and air delivered munitions upon urban areas has proven to be counterproductive in the past.	(3) Indirect artillery fire and air delivered munitions should have more precision for use in built-up areas, possibly requiring precision guided munitions and improved fire support coordination capabilities along the lines developed in this report.
(4) Movement in the streets and in the hallways of buildings is extremely dangerous and indicates a need for a readily available wall-breaching capability.	(4) The Army Materiel Command should be encouraged to develop wall-breaching devices and munitions for employment at the small unit level to meet the needs of urban combat.

(5) Significant differences exist between U.S. and Soviet doctrine and tactics for the penetration and destruction of city defenses with armor, artillery, and infantry.	(5) Modification of U.S. doctrine and tactics for the attack of built-up areas should be considered for both the attack of built-up areas and the defense of cities such as those in Western Europe.
(6) Snipers are extremely important in urban combat, especially when operating in teams for ambush and mutual support.	(6) Sniper training programs should be upgraded to exploit their potential in urban combat.
(7) Private and commercial vehicles will affect combat in built-up areas. Refugee traffic may seriously impede military movement, or the urban defender may purposely choose to use automotive vehicles to construct barricades and other obstacles. Automotive vehicles can also be pressed into service for transportation, to provide cover and concealment, or as locations for boobytraps and off-route mines.	(7) The presence of large numbers of private and commercial vehicles must be considered by military planners when formulating movement schedules into, through, or out of built-up areas; traffic control and clearing of refugee traffic will often be a critical problem. The potential use of automotive vehicles for troop transport or other military purposes must be recognized and integrated into the doctrine, training, and planning for urban combat.
(8) Grenades of all types are primary munitions for city fighting.	(8) Because of their great importance and frequent employment in the close-in tactical conditions of urban combat, grenade performance characteristics and rates of expenditure should receive a careful review. Product improvements, new designs, increased production, and an expanded logistical pipeline may be warranted.

IV. SELECTED WEAPON SYSTEMS & TACTICS

The remainder of this analysis centers around the evaluation of selected weapon systems and tactics. There are four subsections and each contains one or more concepts.

IV.1 <u>Individual/Personal Weapons</u>

Rifle

Grenade/Grenade Launcher

Combination Weapon

IV.2 <u>Large Caliber Squad Weapons</u>

Wall Breacher

AT Weapons

IV.3 <u>Infantry Support Weapons</u>

Artillery

Aerial Fire Support

Armor

Precision Guided Munitions

Mines

Smoke

IV.4 <u>Infantry Tactical Concepts</u>

Urban Reconnaissance Patrols

Airmobile Support

IV.1 Individual/Personal Weapons

IV.1.1 Capability of Current Individual Weapon Systems

The Army currently has two standard rifles, a side arm, a grenade launcher, and a combination weapon which consists of a rifle and grenade launcher on a single frame. All are available in quantity for use by forces fighting in cities. Using these weapons, the current capabilities in the urban environment were reviewed with respect to:

Accuracy
Sustainability
Portability
Reliability
Penetrability

These current capabilities are summarized below.

(1) Accuracy - The threat against which the infantryman operates is normally the enemy soldier with his individual weapon. Unlike the rural threat, the urban enemy can make maximum use of hard cover and concealment to the extent that he almost always fires from a prepared position. His position is difficult to detect and exposure is kept to a minimum. Consequently, targets are even smaller in cities and almost never move in the open. In terms of time, exposure is also at a minimum.

Engagement ranges are typically short -- less than 50 meters. Almost all weapons are inside or behind barricades. Interlocking fires are used by the defenders. The targets are very small (top of the head, half of a face), fleeting, and difficult to detect. In most instances targets will be engaged with hastily aimed rounds. In terms of the accuracy required to achieve a hit (.5 mil at 50 meters), this places an almost impossible task on the infantryman and his individual weapon.

Figure 11 shows resultant accuracies of the M14 and M16 when fired at surprise targets at close ranges. The targets are E-type

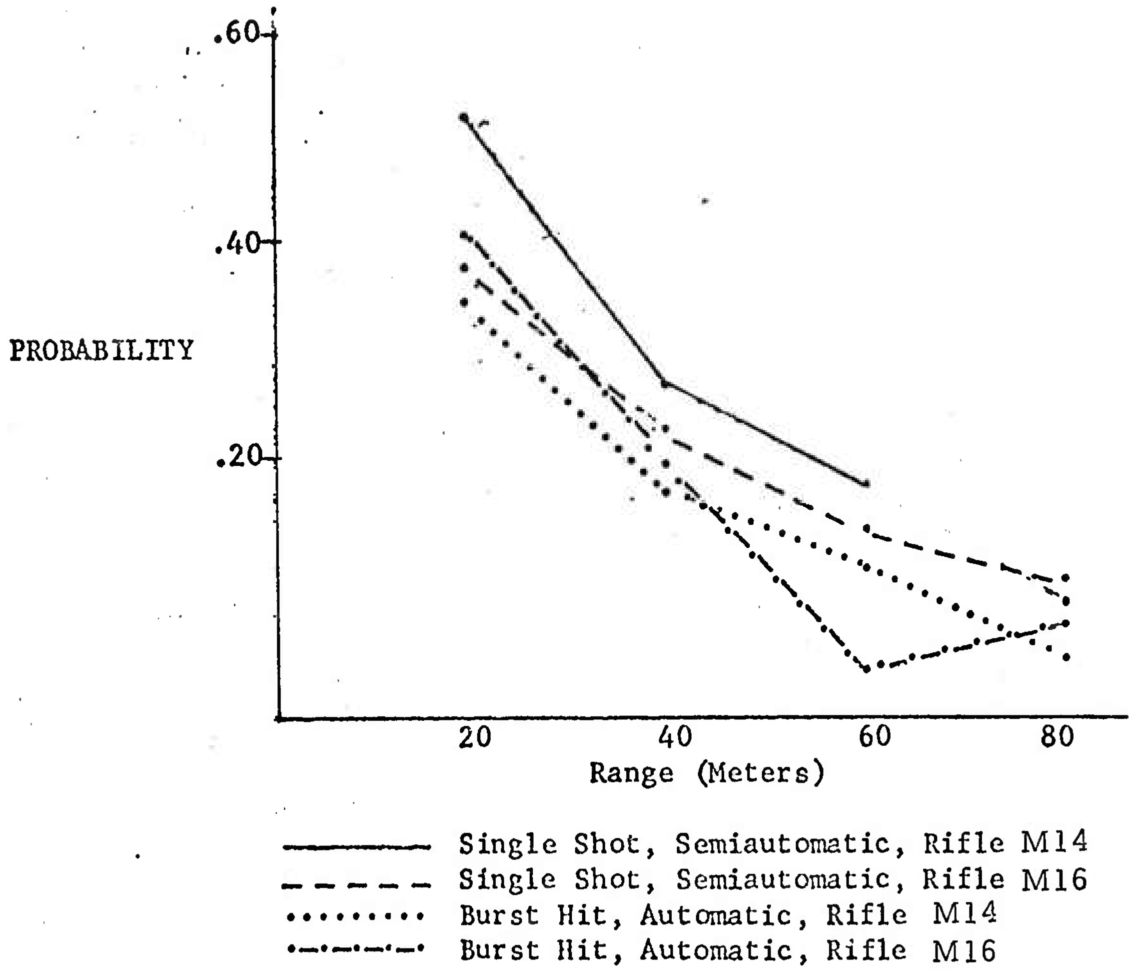


Figure 11: Hit Probability Versus Range

silhouettes, the figure of a man from the waist up. The figure shows the semiautomatic mode to be a better hit producer per round expended than the automatic mode. This suggests that the individual firing in the automatic mode is relying on the hose effect to hit the target, rather than on aiming. At 20 meters, the hit probability (P_h) is about .4. Figure 12 shows the time required to acquire, aim, and shoot with the current rifles as a function of mode of fire. Note that the time to fire is somewhat shorter for the automatic mode of fire, reinforcing the conclusion that the soldiers take less time to aim the weapon and rely more on the volume of fire. Figure 13, a weapon comparison, shows that approximately 2 1/2 seconds elapse from target appearance to first round fired for the M14 with the M16 somewhat slower. This is perhaps due to the raised sight, straight barrel configuration of the M16, which does not permit a shotgun type point at the target prior to alignment of sights. Figure 14 shows the time to first hit. Revising these figures to compensate for the reduced exposed areas and the hard cover of urban combat, one can expect P_h to be reduced by a factor of 10. All of the figures were compiled during methodology tests at the U.S. Army Infantry Board at Fort Benning in 1968.

Limited data on M16 rifle performance against moving targets are available. Against a man-sized target moving at 4 to 8 mph, the hit probabilities are approximately one-half of the values for stationary targets. See Figure 49: Estimated Hit Probability for the M16 Rifle in the Defense Role, paragraph IV.3.6.

For the grenade launcher, experience at Hue indicated that the M79 lacked the accuracy necessary to place a round through a window consistently at 50 meters.[1/] It was determined that the weapon had

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1/ Interview with U.S. Marine Battalion Commanders who led units in the Battle for Hue, Conference, Urban Combat, Picatinny Arsenal, 14-15 March, 1973. See Appendix B.

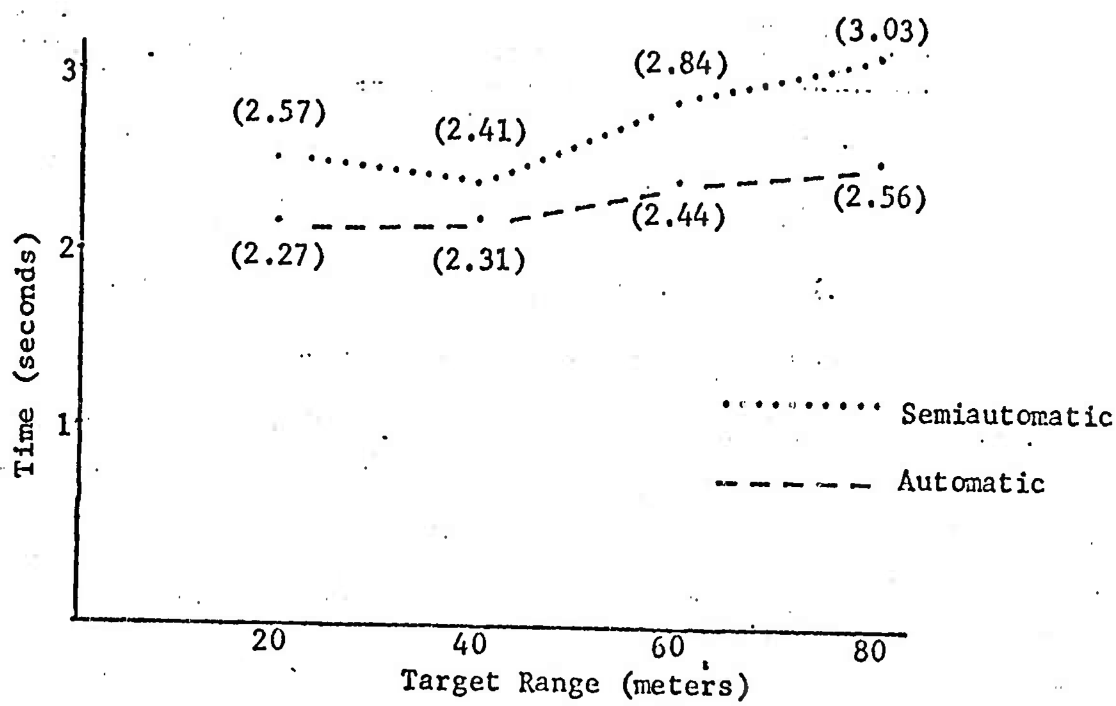

Figure 12: Average Time to First Round (Both Rifles)

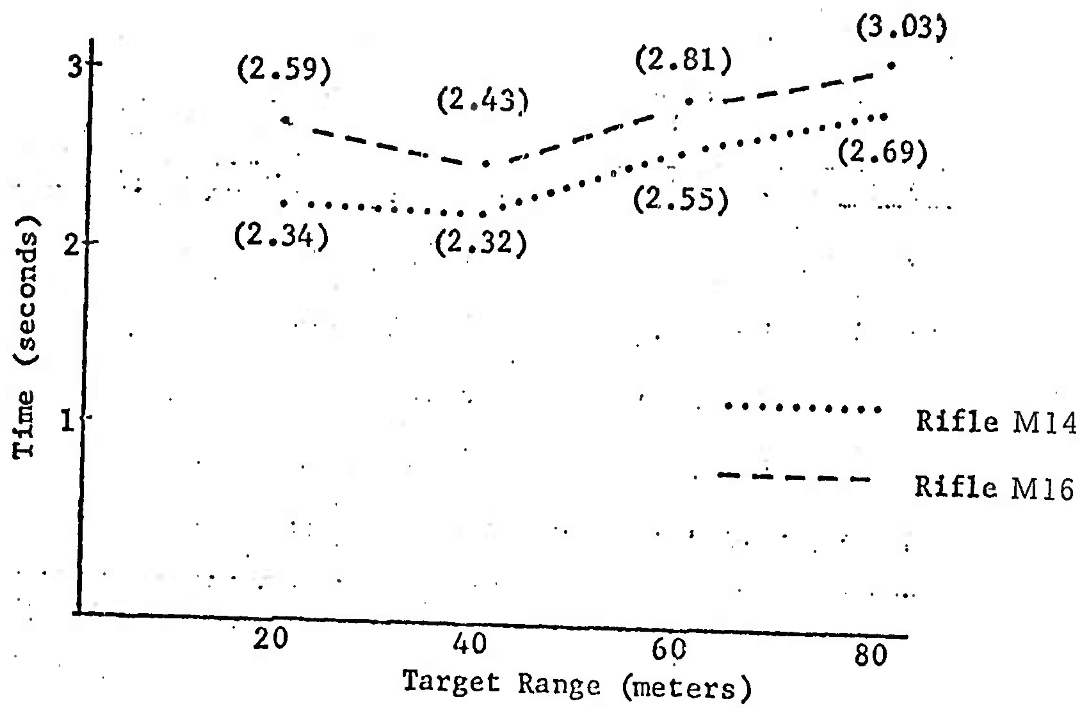

Figure 13: Average Time to First Round (Both Modes)

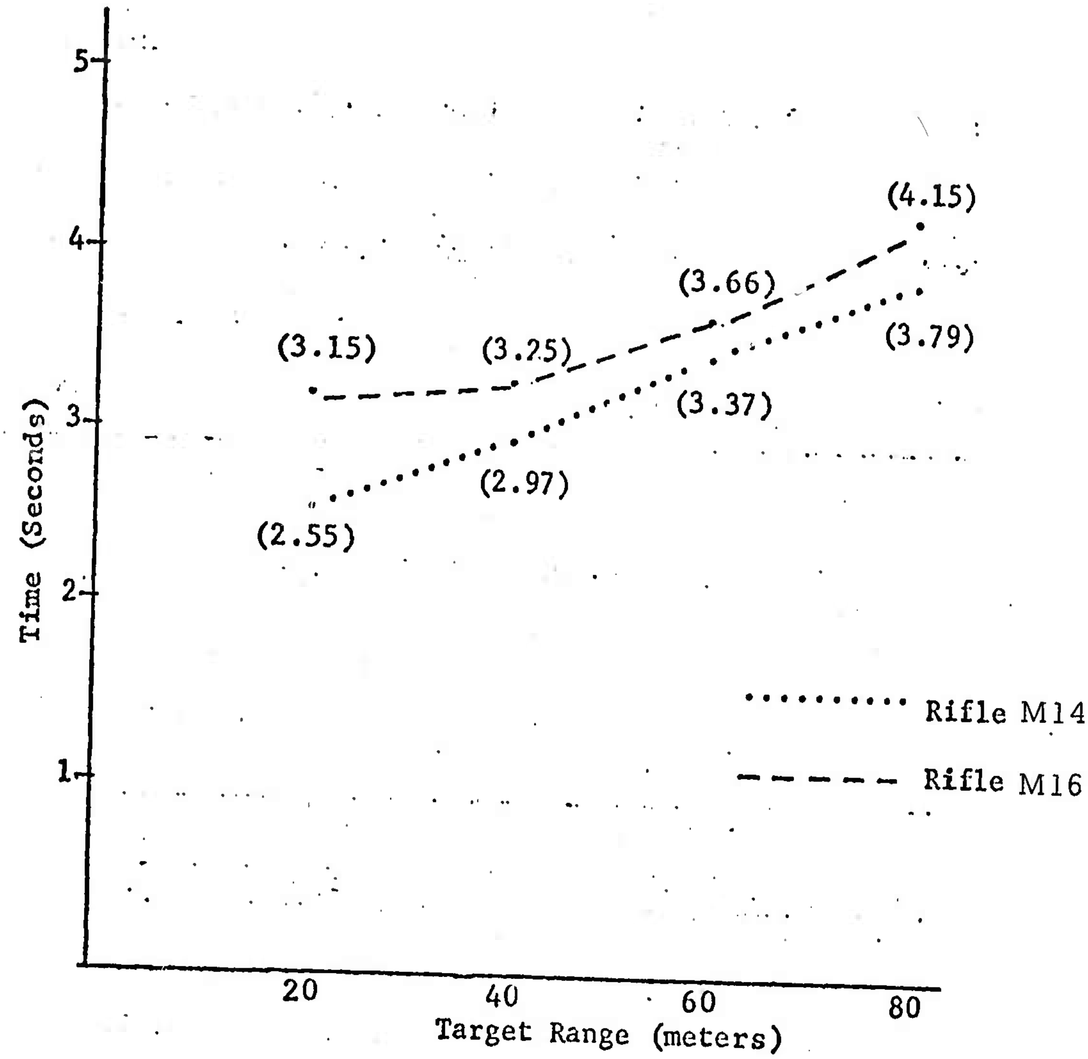

Figure 14: Average Time to First Hit (Both Rifles)

the inherent capability to achieve the task, but that the hasty manner in which the troops had to fire while being fired at caused the rounds to miss the target.

The combination weapon (M203) is made up of the M16 and an attached grenade launcher. Although accuracies will differ somewhat from those described above for the M16 and M79, the differences will be relatively minor.

The side arm is used primarily as a personal defense weapon and therefore is not included in this analysis.

(2) Sustainability - Sustainability is a term used to describe the ability of a weapon system to remain in a sustained fire fight without ammunition resupply. This is a particularly important characteristic of urban combat since lengthy engagements can take place within a confined area such as a single building to which access is difficult. During the battle for Hue, a two-day fire fight took place over the possession of a single building. A description of the Hue battle is included in Appendix B. The description is presented in an interview format; the interview was conducted with two Marine battalion commanders who led U.S. forces in Hue.

As shown in Figure 15, the M16 is far superior to the M14 with regard to this characteristic. The figure shows the percent of the ammunition basic load expended per short-range engagement. In terms of overall system weight, the M16 with 300 rounds of ammunition is equivalent to the M14 with 100 rounds. Further, because of the smaller ammunition, increases in magazine capacity favor the M16 for further weight reduction.

The M203 presents a minor problem in that the weapon weight increases approximately 4 pounds which reduces the basic load. Further, the optimum mix of 5.56 mm and 40 mm ammunitions for city fighting is not known.

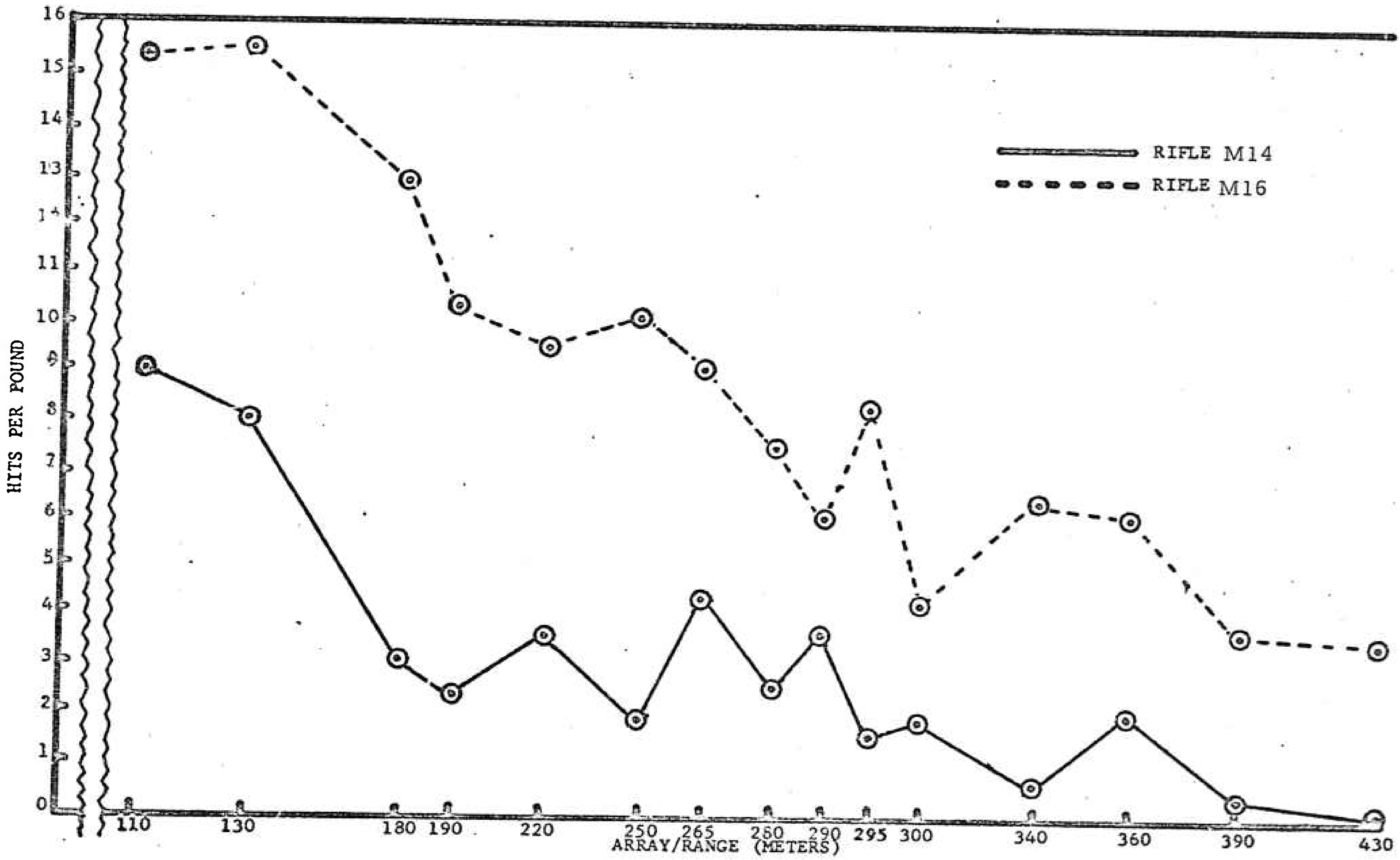

Figure 15: Hits Per Pound - M14 vs. M16

(3) Portability - The lighter M16 is definitely easier to carry and handle in the close confines of the city. Movement through mouseholes is more difficult with the heavier and more cumbersome .30 cal weapons. The use of a submachine gun would further improve weapon portability.

(4) Reliability - The mean number of rounds to failure* for the two service rifles are: M14 = 400 rounds and M16 = 120 rounds (as measured during operational tests at USAIB). These figures are from 1968 data and perhaps do not reflect recent modifications which could have a favorable effect of the M16 reliability. For the M79 with its relatively simple design, there does not appear to be a reliability problem.

(5) Penetrability - The performance or effectiveness information concerning target vulnerabilities in the urban environment presented in the following pages was assembled from several sources. No single, large sample, statistically valid information source was found. In reviewing the data, one dominant fact is revealed: current small arms ammunition is ineffective against structural materials when fired at the close ranges associated with combat in cities. Current small arms projectiles show maximum capability to penetrate various types of cover (for example, sills, floors, and sandbags), at ranges that exceed those common to urban combat. Penetration at ranges less than 10 meters is relatively poor. At these close ranges the projectile is stabilized in flight, but when it strikes an object, its yaw causes the projectile to tumble and its high velocity results in a breakup of the round. The fragmented round does not pass through the object. Tests conducted by the Infantry School at Fort Benning consisted of firing rounds through a

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* Includes all types of malfunctions, including failure to feed and damaged cartridge.

standard World War II barracks hardwood floor and ceiling. Rifle ammunition failed to penetrate. Figure 16 illustrates this phenomenon.

The figure shows that for both the M14 and M16 rifles maximum penetration occurs near 200 meters and penetration is severely reduced at ranges less than 25 meters. The XM19 projectile appears to have different penetrating characteristics entirely: penetration of the laminated pine boards is almost uniform out to 400 meters. The slow moving .45 cal round also displays different penetrating characteristics. It appears that none of these rounds has the desirable penetrating characteristics needed in city fighting.

Figure 17 contrasts the penetrating capability of the .30 cal ball round and the .30 cal armor piercing round at longer ranges against sand. No data were found for short ranges. Improvements in penetrability of the armor piercing round at longer ranges appear to be 25 percent. Table 5 shows a comparison of the same two rounds against dry clay and homogeneous armor plate. The armor piercing round appears to be better suited to urban fighting than the ball round. Table 6 shows penetrability for various other structural materials.

Several short firing tests were conducted at Fort Benning which support the conclusion that current ammunition is not well suited to combat in the urban environment. These tests consist of short-range live fire at silhouette targets shielded by various materials. The projectile must penetrate the shield to inflict damage on the target. The result (penetration or no penetration) refers to the shielded silhouette target. Table 7 shows the results of twenty of these firings.

Evaluation of the grenade launcher from information gathered at Hue shows the M79 HE round to have almost no penetration capability.

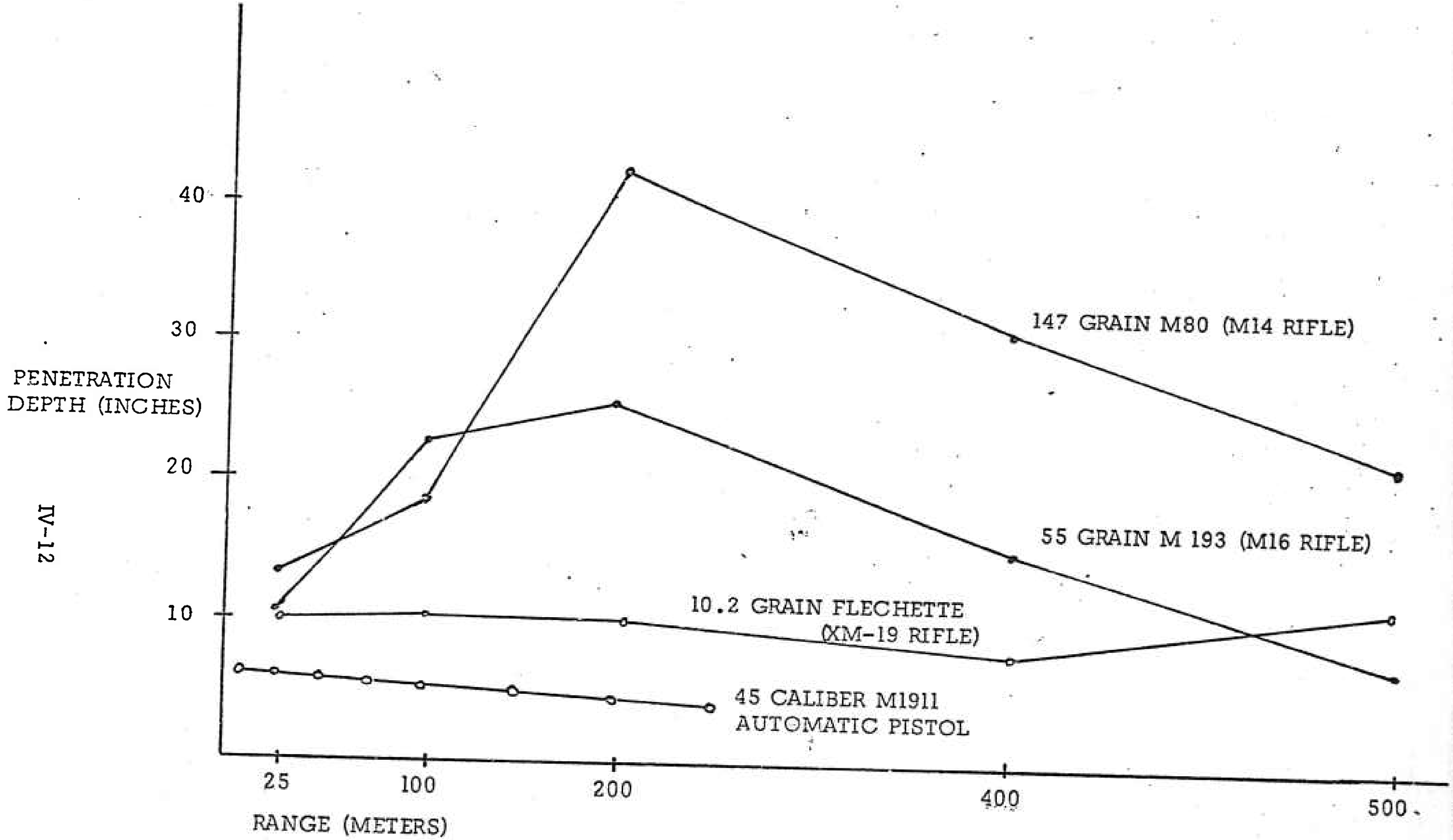

Figure 16: Penetration of Laminated 1 Inch Pine Boards with Small Arms Projectiles

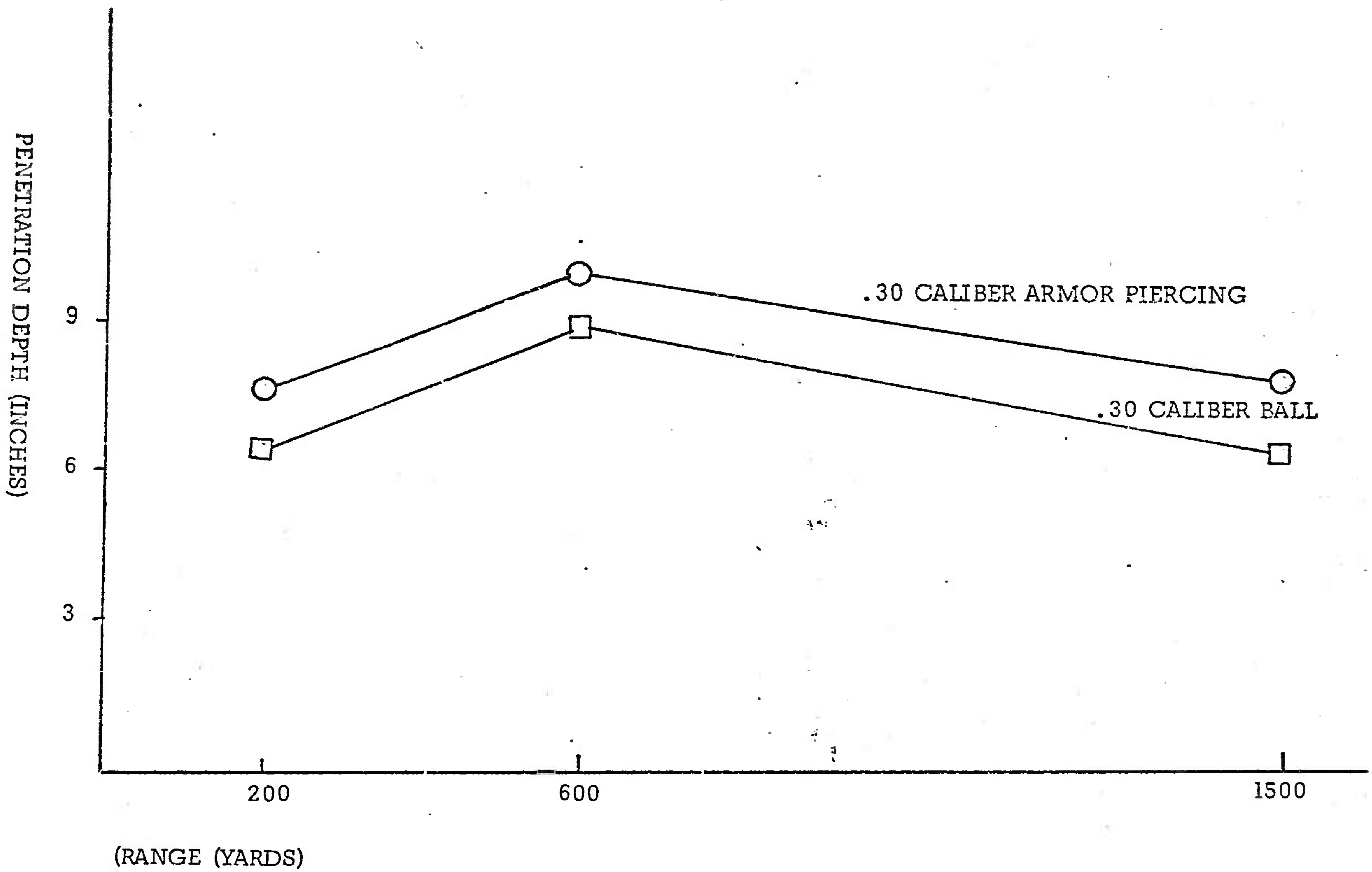

Figure 17: Penetration Into Sand

Table 5: Maximum Penetration of Various Materials at 200 Meters

	Concrete	Homogeneous Armor Plate	Clay (Dry)
.30 Cal M2 Ball	1 inch	.3	16
.30 Cal Armor Piercing		.5	18

P. Penetration Data.

Table 6: Penetration Data 7.62 M80 Ball

Projectile	Range (m)	Striking Velocity (ft/sec)	3-Spaced 1 inch Pine Boards 6 in. apart	Laminated 1 inch Pine Boards- Average Penetration (inches)	Sand Average Penetration (inches)	Concrete Average Penetration (inches)	Concrete* Number of Rounds to Perforation
7.62 147 grain M80 Ball	25	2818	Complete Penetration at all Ranges	13.1	5.2	2.3	------
	100	2648		18.5	4.4	2.3	18th Round Perforated
	200	2423		41.7	7.4	2.3	-------
	400	2051		30.1	11.1	1.6	No Perforation 100 rounds
	600	1741		21.2	12.2	1.4	-------

* Test fired only at ranges of 100 and 400 meters.

Table 7: Penetration Test - M14 vs. M16 Through Various Target Materials

WEAPON	RANGES (Meters)	TARGET MATERIEL	RESULTS ON SHIELDED SILHOUETTS
1. M14	30 and 50	Stacked sandbags horizontally laid one thickness	No penetration
M16			No penetration
2. M14	15, 30 & 50	Vertically standing sandbag	No penetration
M16			No penetration
3. M14	50	Stacked (.50 cal) ammo cans filled with water	All 4 rounds* penetrated
M16			2 of 4 rounds exited can producing fragment holes on silhouette
4. M14	10, 15, 30, 50	Small ammo can filled with sand	No penetration
M16			No penetration
5. M14	30, 50	Window pane at zero obliquity	Single hole penetration
M16			Single hole penetration
6. M14	45	Window pane at 45° obliquity	Single hole penetration
M16			Fragmentation with 3-6 holes in target
7. M14	30, 50	Cinder block filled with sand	No penetration
M16			No penetration
8. M14	30	Cinderblock	Penetration
M16			No penetration

*One round accidentally hit between two stacked cans causing 14 fragments to penetrate silhouette.

Table 7: (Cont.)

9.	M14	15,30,50	55 Gal. Drum filled with water	No penetration
	M16			No penetration
10.	M14	50	55 Gal. Drum	Penetration
	M16			Penetration with some fragmentation
11.	M14	30	Sheet rock 2 thicknesses	Penetration
	M16			Penetration
12.	M14	30	Screen	Penetration
	M16			Penetration
13.	M14	50	Metal Desk Drawer	Penetration
	M16			Penetration
14.	M14	50	Pine door	Penetration
	M16			Penetration
15.	M14	50	3 Pine Doors	Penetration
	M16			Penetration
16.	M14	30	2 x 4 stud	Penetration
	M16			Penetration
17.	M14	65	Single vertical sandbag with wet sand	Penetration
	M16			No penetration
18.	M14	165	Single vertical sandbag	Penetration
	M16			No penetration
19.	M14	10	12 (1"x4") Pine stakes together	Penetration
	M16			10 stakes penetrated
20.	M14	10	12(1"x4") Pine stakes spaced 5" apart	Penetration
	M16			6 boards penetrated

IV.1.2 Functional Area Interface for Individual Weapons

The functional areas of interest are Mobility, Surveillance, Communication and Civil Interaction. For small arms fighting these are not major problem areas. The problem of Mobility or movement in close quarters has been discussed above. For squads and larger groups of infantrymen, Mobility is further discussed under Air Assault Operations in Urban Areas, paragraph IV.4.2.

Surveillance does have a particular impact, especially for sniper and antisniper fighting.

The Marine commanders in the battle for Hue mentioned that Communication difficulties did not exist between battalion and company and between company and platoon. In fact, subordinate commanders were often visible due to the cramped fighting space (battalion fronts were often only three blocks wide). Some Communication difficulties did exist at the extremely low levels between fire teams and individual fire team members who could often be fighting on different floors of the same building. Our current capability with reference to small arms effectiveness may be lacking in terms of inter- and intra- squad Communication.

For the Civil Interaction interface, there are many areas such as population movement, debris, and so on that are related to Firepower. However, most of these are more closely related to other than small arms Firepower. The primary problem for small arms is that of penetration. As mentioned above, current small arms have relatively poor penetrating characteristics at close range which improve with increasing range. This means that an enemy soldier across an alley may be safe from small arms fire if he is behind a window sill, but a civilian several blocks away behind the same type of sill could be killed by a stray round. For city fighting, revising the penetration characteristics would help this problem. Firepower would be more effective at extremely close

ranges, and at longer ranges lethality of stray round would be reduced.

Because of the importance of sniping in urban warfare, it is necessary to address some attention to this area under the general category of small arms weapons systems. The current sniping systems for the U.S. Army and Marine Corps are the M21 and the M40. The M21 was the U.S. Army sniper rifle used in Vietnam. It is an accurized version of the 7.62 mm M14 capable of mounting a daylight and night vision sight. It has an effective range of 900 meters, far more than will usually be needed in the urban environment.

The Marine Corps M40 system is a modified version of the Vietnam vintage Remington Model 700. The modifications include a stainless steel barrel, a reconfigured stock to allow use of day and night vision sights, and the optional use of a bipod or sling during firing. The effective range of the M40 system is 900 meters during daylight and 600 meters at night.

In addition to these systems there are some fairly recent pieces of hardware that should improve current sniping capabilities. Among these should be mentioned the Frankford Arsenal sighting system and the new developments in small laser range finders. These systems when fully developed will allow U.S. forces engaged in sniping to threaten targets at great ranges both day and night.

A Commandant of the Marine Corps decision in 1969 deleted scout-sniper units within infantry regiments and reconnaissance battalions effective in 1972. It appears that the sniping programs in both the U.S. Army and Marine Corps have been downgraded as the Vietnam war terminates. From the standpoint of combat in built-up areas this is most important. Historical research has shown the tremendous impact that a few good snipers can have in an urban conflict, particularly in the defensive role. Snipers took enormous tolls among

the Germans at Stalingrad and have been involved in every U.S. urban action since the Korean War. Sniping systems are relatively inexpensive considering the impact that they are capable of achieving. They are one of the few low-cost, high-performance systems that our research has come upon in the MOBA study.

IV.1.3 Development of New Systems Candidates

Many scenario situations were analyzed to determine the range of firepower tasks that the infantryman must face. The capabilities of our current small arms systems were used as a baseline performance level against which new small arms concepts were evaluated in performing these tasks. The following major types of improvements for small arms were considered:

- Nonlethal weapons
- Ammunition improvements
- Weapon improvements

(1) Nonlethal Weapons - One of the most important differences between urban combat and its rural or open area counterpart is the proximity of noncombatants. In terms of decision theory the traditional two-person zero-sum game becomes a three-person non-zero-sum game. In terms of practical decision making, the urban battlefield is a much more complex environment for every participant from the commander to the rifleman. In the scenarios analyzed, over 75 percent were situations in which noncombatants were in or moving through the combat areas. In Hue civilians were driven into U.S. Marine positions by North Vietnamese troops.

The development of nonlethal close combat weapons could help reduce the complexity of urban combat situations.

There is a considerable body of techniques for determining the expected lethal performance of weapons. When the usual considerations of maximum lethal performance hold, existing techniques provide a ready

means for singling out new concepts with high potential for development. Less promising concepts can be set aside. Traditionally, the selection process is based, generally speaking, on the single criterion of maximum casualty production or damage.

However, there exists no comparable body of techniques for determining the nonlethal effectiveness of a weapon. When weapon considerations turn to low-lethality or nonlethal performance, complications arise. Broadly speaking, there are three performance aims for this type of weapon consideration: (1) selective lethality or damage, (2) controlled lethality or damage, and (3) minimal lethality or damage. Further, the performance aim of maximum nonlethal incapacitation while achieving selective, controlled, or minimal damage is imposed on so-called low-lethality or nonlethal weapons.

The existing body of techniques for evaluating and rating the potential performance of this relatively new class of weapons is extremely limited. First of all, the evaluation requires techniques based on two criteria: (1) lethality (or the lack thereof) and (2) nonlethal incapacitation. Second, the inclusion of the new criterion of nonlethal incapacitation requires operational data which is poorly known or simply not available in some cases.

As a result, the study of the Firepower functions of "Military Operations in Built-Up Areas Overseas" required an effort to establish the rationale and lay the foundation for a systematic technique of evaluating and rating the performance of low-lethality and nonlethal weapons.

Some conditions of operations in built-up areas will dictate a desire for selective lethality. Such conditions occur when two or more classes of targets are intermixed -- say, personnel and structures, or enemies and noncombatants. In such cases, the desired weapon performance may be maximum lethality or damage on one class of target and

minimum lethality or damage on another class of target. The techniques for this type of weapon performance evaluation seem most straightforward and readily adaptable from existing conventional techniques.

Controlled lethality or damage is required. For example, in seeking to persuade hostile forces to surrender or abandon a position (assumed to be a desirable objective), it might prove effective to demonstrate the lethal capability of the friendly forces through the application of a controlled, limited level of casualties. TPRs 5, 18, 24, 25 (Appendix A) specifically address this type of problem. Alternately, it may be desirable to incapacitate a facility for a specific limited time through controlled destruction of one element of that facility. Such conditions imply two things: First, a narrow band of lethal or damage potential is sought, and a weapon's performance must be rated on its ability to stay within the desired limits. Second, the definition of a band of desired lethal or damage performance implies the corollary function of incapacitation as a result of damage. The first requirement for a performance rating was met by qualitatively adapting and extracting techniques from the conventional methods of performance rating. The second, however, required a new body of thought in the areas of definition of incapacitation criteria and quantification methods for these criteria.

Establishing the performance of a weapon under the requirement for minimum lethality or damage implies the adaptation of current techniques. It was necessary to minimize rather than maximize the same standard lethality function.

An extensive review of nonlethal weapon concepts was made using the actions described in the detailed action scenarios (see TPR 9, 14, 18, 25, Appendix A). In every case, it could be determined that their use would cause a significant increase in friendly casualties as long as the enemy continues to use conventional firepower. Nonlethal concepts reviewed were:

- Animals
- Sticky devices
- Electrical charges
- Lasers/light
- Aerosols
- Foam
- Bludgeons
- Rubber, water or bean bag projectiles
- Disintegrating projectiles
- Acoustics

Figure 18 shows that the number of unknowns increases with respect to terms of development, training, and acquisition.[1/]

Chemical systems such as tear gas, CS, and smoke have already proved their worth in urban combat and were found to have a relevant role in the scenario analysis (see TPR 22, 24, 26, Appendix A). However, performance data are not available for detailed analysis. Further, their availability for the time frame of interest is questionable. Looking only at kinetic energy weapons (Figure 19), the relationships between weapon type and lethality can be described graphically.[2/] Against unarmed or lightly armed personnel, such as in a riot control action, these systems may have value. Against a heavily armed, trained enemy force, nonlethal kinetic energy weapons for the near future do not have sufficient capability to counter conventional weapons.

1/ Less Lethal Weapons for the Civil Disturbance Control Mission, Dr. David Stefanye, U.S. Army Materiel Command, Washington, D. C., P. 11.

2/ Op. cit., P. 12

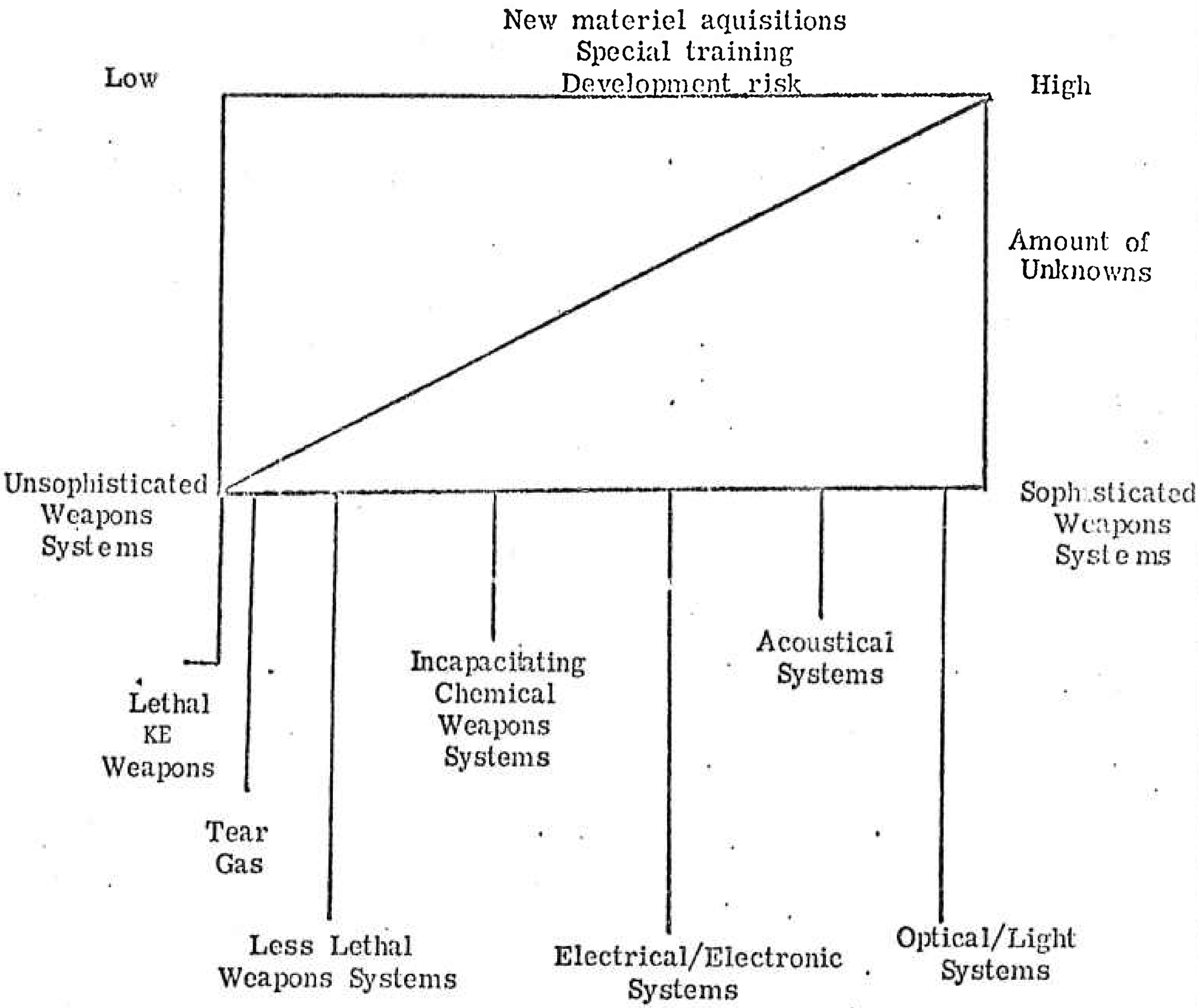

Figure 18: Relationship Among Weapons Systems and Development Factors

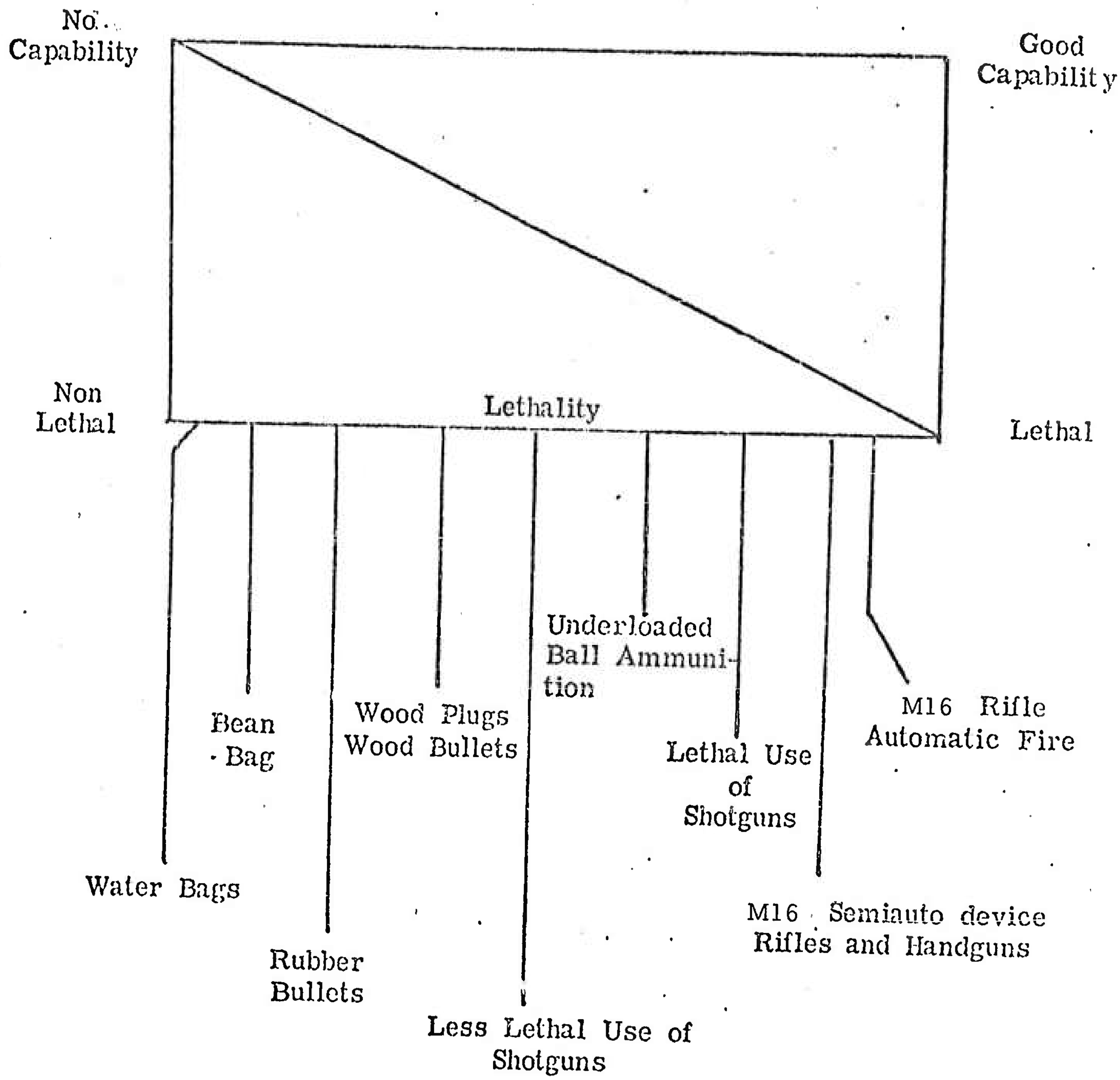

Figure 19: Nonlethal KE Weapons and the Combat Capability

It was concluded that none of the concepts that were free from simple countermeasures were technically feasible within the 1975-80 time frame. Reduction of civilian casualties would have to take place using other means. Concepts such as precision guided munitions and an improved fire direction center could significantly reduce civilian casualties, but for the present, in mid-intensity conflict, nonlethal weapons could not effectively replace current individual weapons.

(2) Ammunition Improvements - Improving the ammunition component of current munitions was found to be a method of improving current firepower. The improvement is achieved by means of a trade-off. There is far less need for a single projectile round with a maximum effective range of 400 meters for the rifle and 600 or more for the light machine gun. The velocity and precision can be traded for more projectiles. Using a duplex or triplex round, hit probability against extremely small targets increases, and there are no penalties in terms of quickness or responsiveness. A soldier can fire a single three round projectile just as quickly as the single round. The area in which accuracy is degraded is beyond the normal engagement ranges. Table 8 summarizes accuracy data for the duplex round. These data were collected during evaluation of the .30 cal duplex round at Fort Benning, Georgia. Table 9 shows the results at the shortest range for which data are available.

The lack of ability of current munitions to penetrate various structural materials is another area in which improvement in performance is possible. Figure 20 illustrates the potential improvement in penetration if stability and integrity of the projectile can be maintained at impact. Reduction of cover has the effect of enlarging the target since more of the target becomes "visible." These trade-offs suggest that it may be

Table 8: Duplex vs Standard - Cal - .30

(Ranges 100 - 800 Meters)

	Target Hit		Killed	Combat Action
	Number	%		
Duplex	517	27.8	410	Day Defense
Standard	460	24.5	354	
Duplex	492	41.2	377	Day Attack
Standard	455	38.3	339	
Duplex	220	46.6	187	Night Defense
Standard	177	37.7	132	
Duplex	128	26.8	99	Night Assault
Standard	86	17.9	65	

Table 9: 100 Meter Target Hit Data

	Rounds Fired	Targets Hit	P_h
M62 (Standard)	1227	187	.152
M80 (Tracer)	1040	178	.171
M198 (Duplex)	1097	279	.254

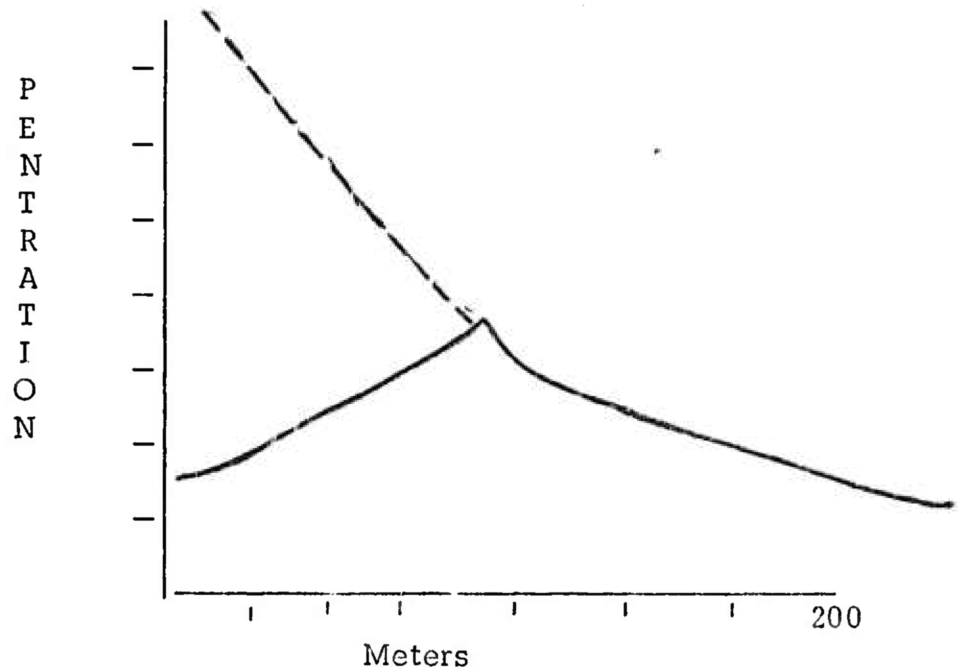

Figure 20: Potential Penetration Improvement

desirable to develop a "city" round for the M16 rifle which will significantly improve its performance in the close combat environment of urban areas.

Other improvements in ammunition include the development of a "shot" round for the M79 or M203 grenade launcher. Such a multi-projectile round could be an effective anti-personnel round for ranges under 50 meters. Again, this round would increase the probability of hitting targets partially visible behind cover and would decrease reaction time by permitting wider use of the point-fire technique.

(3) Small Arms Weapon Improvements - The concepts described above suggest an alternate approach, that is, the development of a special purpose individual weapon for urban combat. Such a weapon would combine the characteristics of the submachine gun and the multiple projectile cartridge. The most promising multiple projectile weapon systems appear to be the Salvo Squeeze bore (SSB) and the current XM-19 projectiles. Accuracy problems have been experienced with both of these concepts in the past when their development was oriented to the needs of the rural battlefield. Proper projectile dispersion is difficult to achieve and maintain over 600 meter ranges. These constraints can be relaxed in the city where ranges vary from 5-50 meters for the most part. Under these conditions, a .30 to .22 cal squeeze bore with three to five projectiles per round on a submachine gun frame appears to be technically feasible and operationally suitable. Figure 21 shows the potential improvement of a projectile SSB round over a standard 5.56 round when fired at a running target partially visible behind a low wall. Using aiming probable error of 9 mil to reflect combat degradations and a projectile dispersion of 3 mil around the bore line, the increase in hit probability was obtained by a simulation, yielding the results shown in Figure 21.

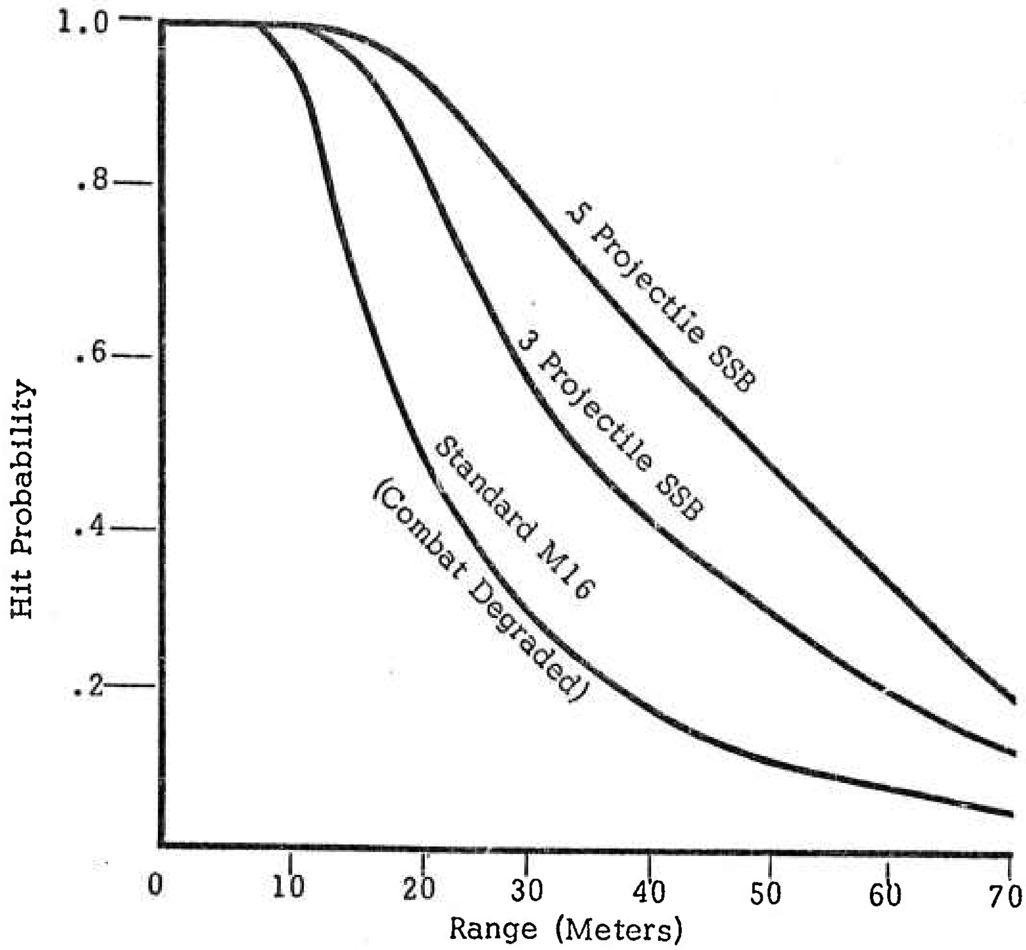

Figure 21: SSB vs. M16 Round Against Partially Visible Running Target

IV.1.4 Individual/Personal Weapons -- Findings and Recommendations

FINDINGS

(1) The operation requirements associated with the employment of individual weapons in an urban environment differ greatly from those experienced in standard field operations. Engagement ranges are much shorter, target exposure is severely limited in time and space, and urban structures provide readily available protection.

(2) Current small arms ammunition not adequately effective against structural materials when fired at the close ranges encountered in city combat.

(3) Reduction of civilian casualties is desired, but the development of new weapons having selective lethality or reliable nonlethal incapacitation capability is not considered to be a feasible alternative to current small arms within the 1975-80 time frame. Nevertheless there is still a potential for special munitions for the individual weapon

RECOMMENDATIONS

(1) The capabilities of current individual weapon systems should be expanded to include considerations of employment in built-up areas and trade-offs with non-urban requirements. The urban operational requirements should be developed in detail and applied in the selection of the next generation of individual weapons.

(2) The mechanisms of small caliber bullet perforation of urban structures should be determined and small arms projectile design changes should be considered for possible improvement of close range performance.

(3) Operational methods of reducing civilian casualties should be examined in lieu of the development of new weapon systems designed for selective lethality or nonlethal incapacitation capabilities. The technical feasibility and logistical implications of providing special incapacitating munitions for existing systems warrant more detailed

capable of delivering incapacitating effects.

(4) Unaimed fire at targets of opportunity at close ranges is much more common in urban combat then elsewhere.

(5) The resupply problems and the lengthy duration of firefights in the urban environment emphasize the importance of the individual's ability to carry an adequate basic load for his weapon.

(6) The development of a special individual weapon for city fighting is technically feasible. The development of a light submachine gun employing multiple projectile rounds appears to be a method of improving the individual man/weapon system significantly for urban combat.

evaluation by the appropriate Army agencies.

(4) The salvo squeeze bore (SSB), duplex, and other salvo system concepts warrant consideration for possible urban combat application. These provide trade-off opportunities for improving snap-shooting performance at the cost of long-range accuracy and should be assessed by thorough cost-benefit analyses.

(5) Any new individual weapon system and its ammunition component should be light in weight to permit the individual to carry large numbers of rounds in his basic load and to move in the close confines of intra-building combat.

(6) The development of a weapon concept combining the characteristics of the submachine gun and the multiple projectile cartridge should be considered for urban combat applications. A thorough analysis should be undertaken to determine the mission advantages vs. the logistical impacts of adopting such a system.

IV.2 Large Caliber Squad Weapons

IV.2.1 Wall Breachers

(1) Analysis of Current Capabilities - The Army currently has no weapon system especially designed for wall breaching. There are combat engineer vehicles with demolition capabilities such as the 165 mm demolition gun which uses a large HEP round. The resulting blast will penetrate about 7 feet of concrete and will open a hole approximately 1 foot or so in diameter. Any of the large caliber weapons such as artillery weapons, tank guns, and RRs have some capability as wall-breaching systems. However, these systems are tactically ill suited for city combat because of their cumbersome size, lack of mobility, and high vulnerability in the urban environment.

Analysis of historical combat experience and scenario situations has highlighted the need for a man-portable wall-breaching system for urban combat. The wall-breaching capability should include both hand-emplaced (satchel) devices and remote (across-the-street) capability. The hand-emplaced device would be most useful in a room-to-room clearing operations. The remote breacher would be used to obtain access to a building or fortified position.

Current munitions that occur in high density can be placed in three categories -- fragmentation, kinetic energy, and shaped charge. These warhead types have been efficiently designed for propelling fragments or for penetrating thick armor but were not designed to breach thick concrete or masonry walls, and their efficiency at this task is very poor.

Tests conducted recently at Picatinny Arsenal* on the LAW, the 3.5 in HEAT rocket and a special HEP rocket showed that these weapons

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* Technical Report 4344

were inefficient wall breachers -- four or more rounds were generally required. The tests simulated the attack of a barricaded building in an urban area. The target was defined as a conventional 8-inch thick brick and mortar type wall backed by 4 feet of sandbags. The desired terminal effects were defined as a 2-foot-minimum diameter hole suitable for entrance by forces assaulting the barricaded building.

The 66 mm M72A2 LAW rocket was eliminated from consideration during preliminary screening -- five rounds had not produced the desired results. The 3.5 in M28A2 HEAT rocket appeared to be the prime off-the-shelf candidate while the HEP rocket, after further development, could be the prime specialized weapon. Four 3.5 in rockets were required to defeat the target, but the special HEP rocket defeated the target with one to two fewer rounds (depending on the explosive weight). Explosive weights of approximately 3.3 and 1.8 pounds of cast HTA-3 high explosive were used. It should be noted that the components and warhead size of the special HEP rocket are not considered optimum because the components were selected to quickly demonstrate the feasibility of employing HEP type warheads against the brick masonry wall target. The HEP rockets were constructed using hardware common to the 66 mm M72A2 LAW rocket and the M74 incendiary rocket. The HEP warhead concepts are not optimized designs because the plastic mushrooming effect characteristic of a HEP warhead at impact was not achieved.

In all phases of the tests brick and steel fragmentation was experienced at the launch site, indicating potential danger to an unprotected gun crew at ranges of 100 feet or less.

Examination of the relevant past and present work in the area of wall breaching -- from the old NDRC data to the current efforts at Naval Weapons Center (China Lake), Ballistic Research Laboratories (Aberdeen), and Picatinny Arsenal -- has shown that our capability in this area needs to be upgraded. Current test data in this area are

quite limited and do not provide guidance as to the optimum employment of the current candidate systems. The LAW and 3.5 in rockets can be used to produce man-sized holes in walls if multiple shots are employed, but the optimum pattern of hits for a given structure is unknown. Also, there are significant data gaps as regards safe launching distances.

(2) Environmental Characteristics - Three of the TPRs indicate the type of urban environment in which wall breachers would be employed. The first of these (Firepower 12) is the reinforcement of a Wallonian unit located next to a Rumelian infantry strongpoint. The most dangerous approach to a prepared defensive position in city fighting is through the streets. Emplaced machine guns and antitank weapons dominate the streets and make movement costly; therefore, the Wallonian company moves and fights through the building as much as possible. In Firepower events 22 (El Condor) and 25 (Hung Shan) fighting takes place in reinforced concrete high rise buildings. Building entrance and room-by-room clearing operations are conducted against determined defenders. These three TPRs identify the following pertinent characteristics of the urban combat environment in which wall breachers would be employed:

- Movement along the streets is dangerous if not impossible.
- A building or strong point must be entered and normal access routes (doors and windows) are barricaded and heavily defended.
- Vertical as well as lateral movement inside the building is required, movement along the hallways is analogous to movement along the streets.
- Weapons must be fired at very short ranges and within buildings.
- Collateral damage to the building must be minimized.

- Lethal effects on nearby neutral (civilian) personnel may be counterproductive to the goals towards which the military action is desired.

(3) Functional Area Interface - A wall-breaching capability would improve the infantry unit's ability to move vertically and horizontally in all phases of city fighting: interbuilding, intrabuilding, and street fighting. Thus the wall-breaching capability interacts significantly with Mobility. Effective methods for the coordination of operations inside a building in conjunction with support from forces outside the building are required. Therefore the wall-breaching capability, in providing improved Mobility, interacts with Communications. Improved Communications capability may be required to provide optimum employment of the wall-breaching capability.

(4) Development of New Systems Candidates - The analysis of scenario situations indicated the need for a wall-breaching capability. All fighting units from heavy vehicles to individual troops have a need for wall breachers.

Analysis of current capabilities has shown the need for significant improvement in our wall-breaching capability. This analysis has also identified the technical feasibility of significant improvement in our capabilities. The problem is that our current weapon systems were not designed for wall-breaching, and, therefore, it is not surprising that their efficiency at this task is very poor. However, if the equivalent chemical energy of present warheads were designed for the special purpose of cutting man-sized holes in a wall, large gains in efficiency could be obtained.

Improvement in our current capabilities could be obtained in three ways:

- Improved employment of current inventory items
- Product improvements
- Synthesis of new system concepts

(i) Improved Employment - It was previously noted that significant gaps limit our knowledge of the best way to use current inventory items. Data is needed both on the terminal effects of present weapons against city structures and on the conditions under which these weapons can be safely fired in the urban environment.

The scenario analyses identified the need for two major types of wall-breachers -- a remote breacher and a hand-emplaced device. The remote breacher is required for an across-the-street capability. The wall of the building is breached from a fortified position across the street and troops immediately enter the building under protective fire. Once inside the building, a room-by-room clearing operation is begun. For this operation a hand-emplaced satchel charge would be highly effective. The use of commercial products such as Jet-Axe should be considered for this application. Jet-Axe employs a linear shaped charge to cut a circular hole in a steel reinforced concrete wall. This device is used by fire departments and rescue squads to obtain access to buildings. It might be noted that the problems faced by these agencies contain many of the same elements to be found in urban combat. Access must be obtained to a specific part of the building, time is of the essence, and external conditions prevent entry by the normal means. Thus research and advancements in fire fighting and rescue equipment is of continuing interest in this study.

If a hand-emplaced device such as Jet-Axe could be employed, the wall to an adjoining room could be breached, perhaps without the defenders being alerted to this fact. Immediately after breaching the wall, grenades could be used to neutralize the defenders. Data gaps exist as regards the safe distances at which devices such as this may be used. For example, are the blast pressures and fragmentation effects such that friendly forces could remain in the room, thus exploiting the surprise value of the device?

(ii) Product Improvements - The adaptation of the basic warhead technology into more efficient payload packages appears to be a promising area of investigation. From the limited test data available, it appears that HEP warhead shows considerable promise as a wall breacher and significant improvement is feasible if the warhead is designed especially for the wall-breaching function. The shaped charge principle will also be of primary interest. The technical problems are those associated with redesigning the warhead to distribute the terminal energy to yield the most efficient cutting action. Present HEAT munitions will penetrate many inches of steel but produce a relatively small hole in a reinforced concrete wall for the weight of explosive carried. The linear shaped charge or a cluster of shaped charges appear attractive as methods of providing the required size hole. The resulting novel shaped charge warheads may be able to capitalize on the trade-offs available among projectile accuracy and flight characteristics for the shorter ranges typical of urban environments. The mechanism of in-flight deployment of the shaped charge assembly (linear or cluster) will require exploration. The redesign of existing warheads will involve consideration of the fuzing mechanism (for example, in the shaped charge cluster concept, simultaneous initiation must be achieved). The range of angles of obliquity over which the warhead is effective is also an important consideration. These technical problems must be investigated in collaboration with the appropriate laboratories to insure full exploitation of available technology and data.

(iii) New System Concepts - The state-of-the-art knowledge of present capabilities and possible improvements to present capabilities will allow a logical extrapolation to quantitative characteristics of new systems. It is anticipated that the concepts for systems especially designed for wall breaching will be rather novel in light of present

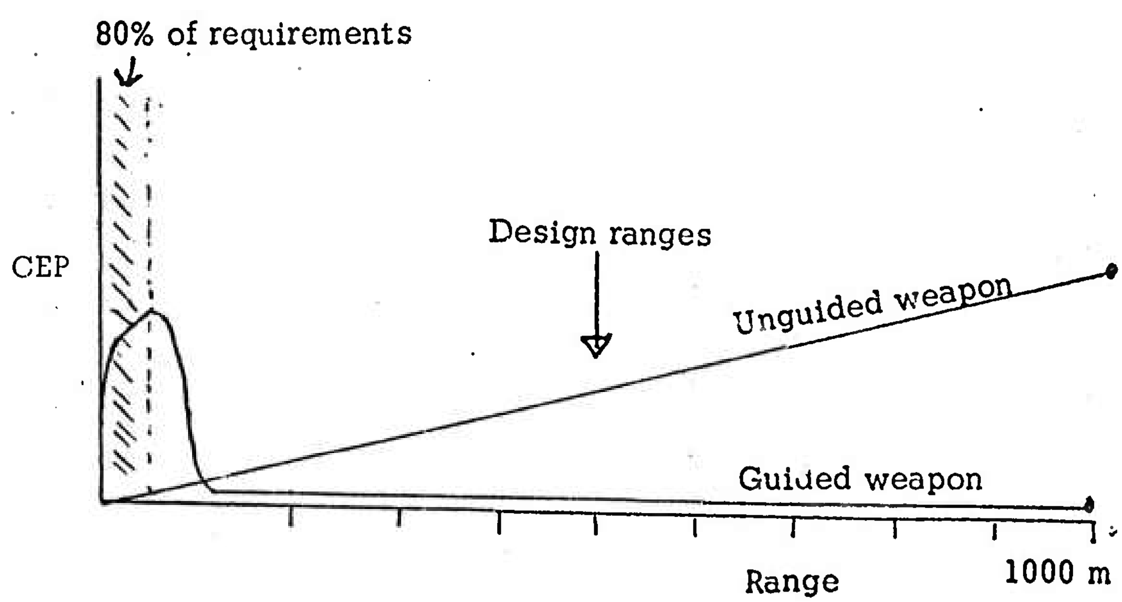
capabilities. One important feature of a wall-breaching system for urban combat is that the maximum range requirement will be quite short (that is, across the street, possibly 10-40 meters). In this respect the wall-breaching system differs markedly from other weapon systems and thus rather novel payload shapes and sizes may be feasible. The problems of packaging these warheads so that they will function through the interior and exterior ballistic environments and deploy properly prior to impact seem amenable to systematic solution.

(5) Wall Breachers - Findings and Recommendations.

Findings	Recommendations
(i) Current weapons systems were not designed for wall breaching and the need for significantly improved wall breaching capability warrants high priority.	(i) Special emphasis should be placed on man-portable wall breaching systems both for building entry and room-to-room movement. It is recommended that Exploratory Development efforts be undertaken along the lines identified in this study.
(ii) Additional data and information are required on current weapon systems in order to properly employ our present capabilities. Data are required primarily in the areas of terminal effects and the launch environment of urban combat.	(ii) Determination of terminal effects for current munitions against city structures should be made and user doctrine for these munitions developed.
(iii) Significant improvement in present capabilities appears feasible through redesign (product improvement) of existing warheads and development of alternative payloads for present systems.	(iii) Development of alternative warheads (especially HEP) for current munitions should be undertaken and related acquisition policies re-evaluated.

IV.2.2 Large Caliber Man-Portable Weapons

(1) Analysis of Current Capability - There are a number of man-portable large caliber weapon systems in the inventory, including the 90 mm RR, 3.5 in rocket launcher (RL), 66 mm LAW, the 60 mm to 4.2 in mortar, as well as DRAGON and TOW. These weapons all have effective ranges of 200 meters and more and absolute ranges of up to 3000 meters. The systems with unguided projectiles are extremely accurate at close ranges, but the circular error probability (CEP) increases with range. The guided missiles, on the other hand, are inaccurate at close ranges (prior to guidance capture) but then work down to a small CEP which remains essentially constant out to the maximum range of the weapon. Characteristically, most of the use of large caliber weapons in city combat occurs at very short ranges (less than 50 meters); so the systems are completely mismatched to the range requirements, as emphasized in the following diagram. In the majority of cases the warheads would not even arm before impact.



The two primary targets for man-portable, large caliber weapon systems in urban combat are tanks and building structures. The frequency with which these two classes of targets will be encountered in urban combat is not known, but historical data and scenario analyses indicates that urban structures will be the most frequent target. Very little data for terminal effect of large caliber rounds against various structural material were found. A test to determine if mouseholes or entry holes could be created with a LAW was conducted. Using a structure similar to the standard wooden Army barracks, it was determined that three rounds fired at the same area would produce a man-sized entry passage. Table 10 summarizes the performance of various large caliber rounds against earth and reinforced concrete.

The results of several tests using flame and CS weapons against a variety of building materials are shown in Table 11. Generally, burning temperatures are rather low and, consequently, little damage normally occurs to such material as brick, plaster, and wood. All weapons are effective against glass and some of the higher temperature weapons are effective against thin steel.

The tank is ill suited for the environment of urban combat, and with the continuing development of man-portable antitank weapons the vulnerability of the tank in city combat will increase. The man-portable large caliber weapon systems currently in the inventory are antitank weapons using the HEAT warhead. The current warheads can penetrate typical city structures, but it should be noted that in optimizing the terminal effects against tanks, the terminal effects against city structures may be compromised. The precision HEAT warhead will penetrate many inches of steel, but when used against a concrete wall it makes a relatively small hole for the weight of explosive carried. Thus the secondary fragmentation effects are not optimized for city structures.

Table 10: Penetration of Large Caliber Rounds in Earth and Reinforced Concrete

Weapon	Earth	Reinforced Concrete
LAW	6'	2'
90mm RR (HEAT)	3.5'	2.5'
106mm RR (HEAT)	3'	2'
DRAGON	8'	4'
TOW	8'	4'

Table 11: Effects on Various Construction Material of Flame and CS Rounds

ITEM	WOOD	PLASTER	CONCRETE/BRICK	STEEL	GLASS
ABC-M9-7 Flame Thrower Burning Temp. 1200-1400°F	Char	Char	Negligible Effect	Negligible Effect	Shatter Thin Glass
56 mm Multishot Flame Weapon & CS Round Burning Temp. 1200-1400° F	Penetrate 1/2" to 1" plywood @ 200 meters	Negligible Effect	Negligible Effect	Penetrate 18 Gage Metal	Penetrate
40 mm CS XM651E1 Burning Temp. 693°F	Penetrate 3/4" white pine @ 200 meters	Possible Penetration	Negligible Effect	Negligible Effect	Penetrate
Grenade, Smoke, WP, ABC-M34	Fragment Penetration 1/4" white pine @ 20 meters	Negligible Effect	Negligible Effect	Fragment Pent. 1/16" hot rolled mild steel @ 20 meters	Penetrate
Grenade, Incendiary, An M14 Burning Temp. 3000°F	Ignite	Char	Negligible Effect	Melt & Penetrate thin steel	Penetrate
Grenade, CS, ABC-M7A2-M7A3	Negligible Effect	Negligible Effect	Negligible Effect	Negligible Effect	Penetrate

It appears feasible to redesign current HEAT warheads to improve their terminal effects against city structures. Also the use of the HEP warhead appears promising against city structures (see Wall Breachers). This warhead is generally not available for the large caliber man-portable weapons being considered here, and the HEP warheads available are not optimized for urban structures.

(2) Environmental Characteristics - The severe urban geometry has the effect of foreshortening the horizon by an order of magnitude over that in open terrain. This is the reason only 5 percent of urban combat engagements take place at ranges of more than 100 meters while 80 percent occur at less than 35 meters, according to some estimates.

The city is a complex of natural bunkers ideal for hiding and sheltering large caliber weapons. Unfortunately, these bunkers are largely unusable for the man-portable weapons in the current inventory since the backblast of recoilless weapons is reflected and concentrated to intolerable levels and produce internal structural failure dangerous to the operator. The relevant FMs and Fort Benning reports definitely caution against using such weapons from enclosures. However, historical data indicates the Marines fired the 3.5 in RL from rooms after clearing them out—but then these were highly motivated Marines!

(3) Functional Area Interface - There are a few interface problems or opportunities out of the ordinary. Surveillance and Communications perhaps serve a more vital role in locating and designating targets than in open warfare.

(4) Development of New System Candidates -

(i) Concepts of Employment - Because of the backblast associated with all the direct fire, man-portable large caliber weapons, U.S. doctrine essentially limits use from inside enclosures to emergency situations. These weapons can be fired from corner rooms in such a way that the breech of the weapon protrudes out one window while the

projectile is sent through the opposite window. A recent Fort Benning study suggests the reduction of signature by firing the weapon with the breech projected into a doorway. (See Figure 22)

Analysis of historical data, especially the battle of Hue, indicates the need for a large caliber man-portable weapon that can be fired from inside enclosures. Firepower Problem 6 of the Technical Problem Resumes also highlights this need. In this scenario a Lenorian Mechanized Infantry Division captures a key railroad tunnel and its access points. The three company defense of the Burgundians is inadequate and the defender's weakness is multiplied by his lack of time for preparation. The attacker's direct firepower from tanks has a telling effect on the defense. Improved antitank weapons for infantry use, especially recoilless rifles or rockets designed to be fired from closed rooms, would have significantly improved the defense.

There are essentially three tasks for large caliber man-portable weapons: (l) defeat of armor, (2) defeat of fortified positions, (3) wall-breaching. (The wall-breaching capability is considered separately in Section IV.2.1.) Fort Benning advises that alleys and rooftops are good locations for defense against armor, as are windows when the enclosure is sufficiently large for the backblast (for example, factories or warehouses). Rooftops provide a good angle of fire at the turret and engine compartment and may even thwart return main gun fire due to the elevation limits.

Most of the fires against enemy personnel will be against fortified positions in building. For current munitions it has been found effective to hit just beneath the apertures rather than putting the projectile through the opening since a hit on a back wall tends to waste the energy by sending it forward. There will be some opportunity for firing at enemy infantry moving in the street or positioned behind rubble, cars, or

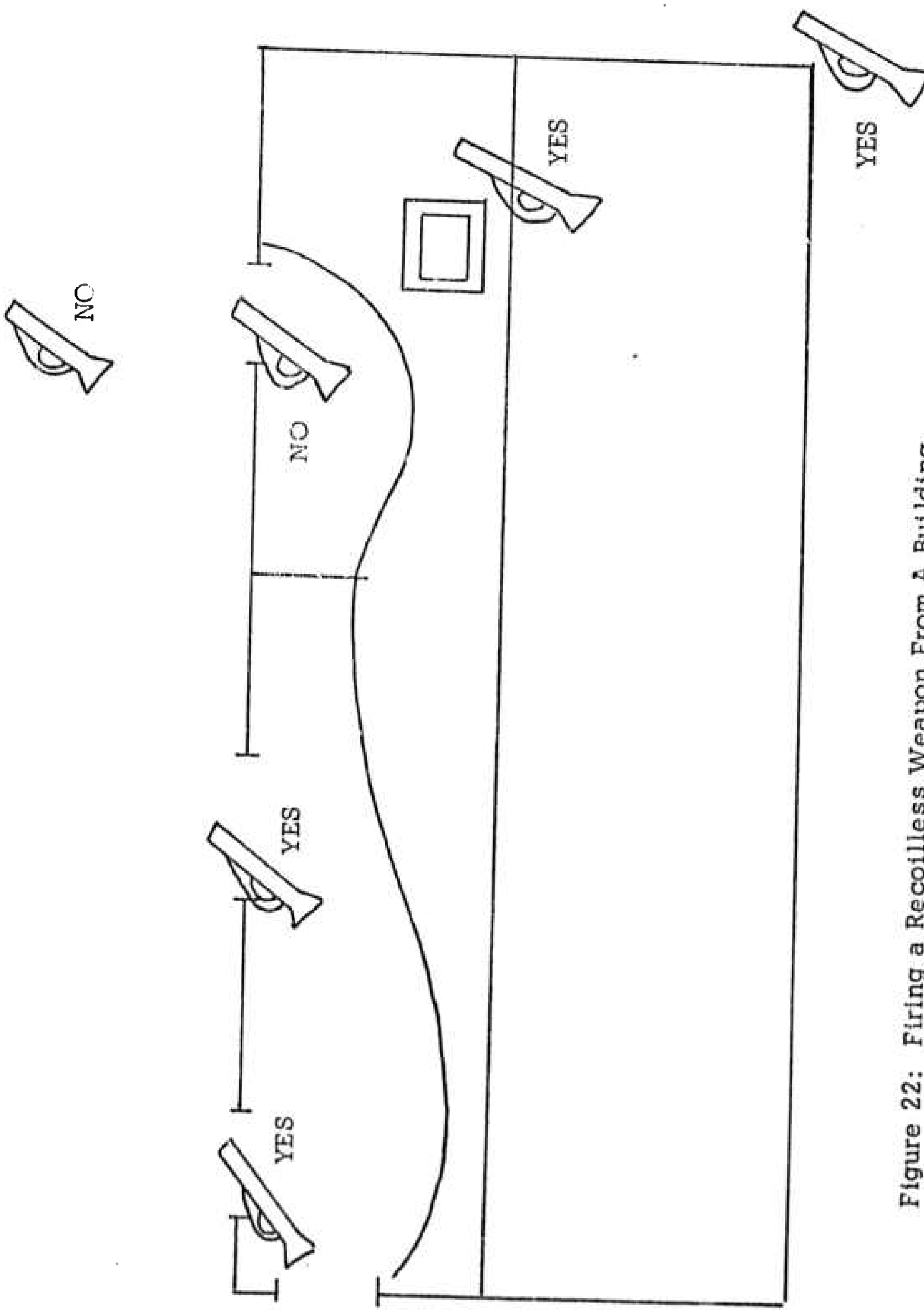


Figure 22: Firing a Recoilless Weapon From A Building

building corners. Here too, the greatest effectiveness is achieved by impacting in front of rather than behind the target, even if this means impacting the protective bulwark -- often the scabbing of the bulwark will cause casualties.

The ranges at which large caliber man-portable weapons are employed in cities are considerably less than in open country. It is felt that the frequency of employment ranges will form the tri-model distribution shown in Figure 23 since the city geometry gives rise to three distinct firing situations which will cover the vast majority of fires: (1) fires from one building across the street to another, (2) fires at or from street intersections, (3) down street fires. These situations are illustrated in Figure 24. It is likely that 90 percent of the fires will occur at less than 50 meters, although this will depend on the average street width.

(ii) Current Combat Task Capabilities - Large caliber weapons are certainly among the most important on the urban battlefield. This was largely true in Hue where often the key battles were between 3.5 in RLs and RPGs (B40s). At An Loc the enemy suffered heavy tank losses to the M72 LAW (although this was partly due to amateurish armor operations). It is precisely because of these weapons that the U.S. armor doctrine is to avoid built-up areas.

(iii) Search for New Systems - There are two main areas where large caliber man-portable systems can and must be improved for urban combat. The first is to permit these weapons to be fired safely from interiors. The second is the reduction of weapon signature.

There are at least five methods for attacking the problem of firing from interiors. In order of promise these are:

- Trade-offs with range performance
- Reverting to in-flight burns

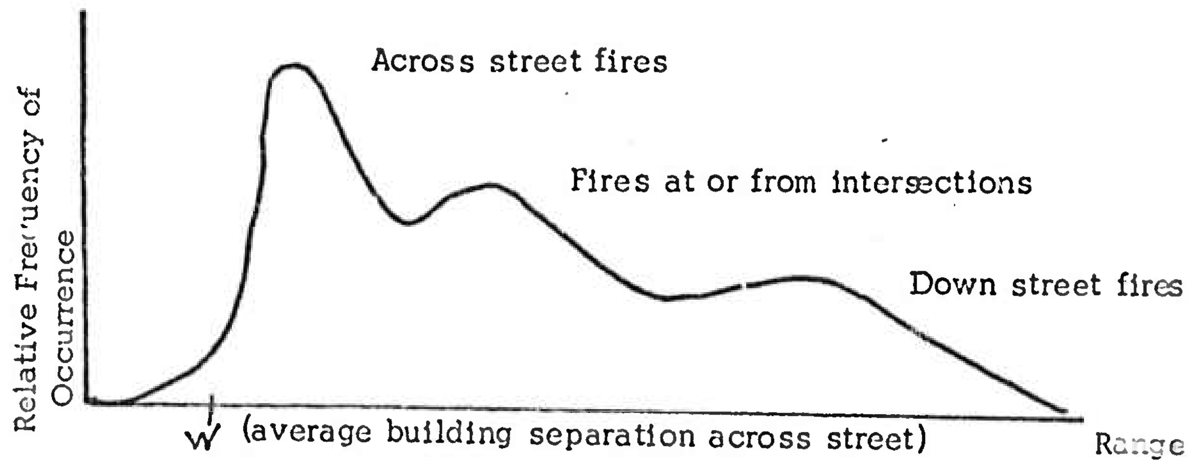


Figure 23: Form of Range Distribution for Large Caliber Man-Portable Weapon

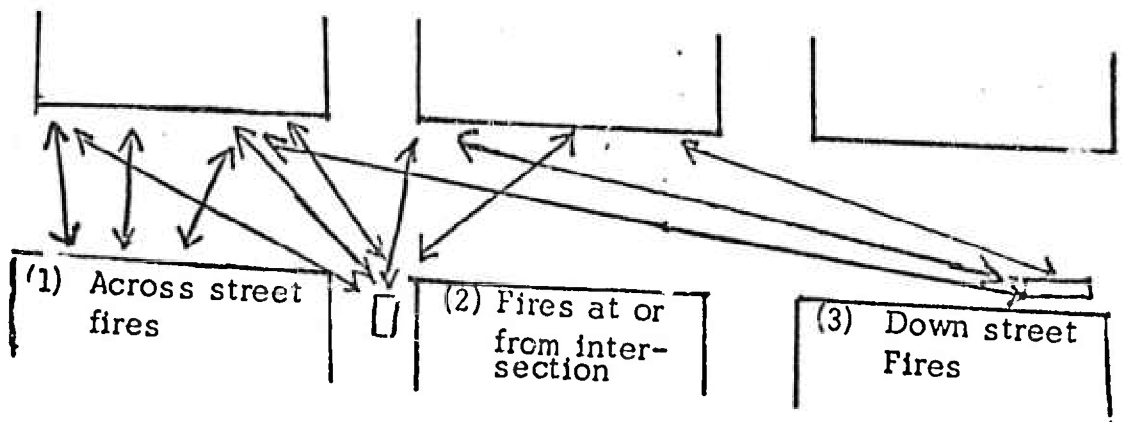


Figure 24: The Distinct Firing Situations in Urban Combat

- Improving operator tolerance
- Preparing building interiors to reduce backblast problems
- Transferring recoil to buildings

These methods for reducing weapon signature are a subset of the methods for permitting use from structures:

- Trade-offs with range performance
- Transferring recoil to buildings
- Preparing or selecting building interiors to obscure the backblast

(iv) Preliminary Design of New Systems - The most promising method for permitting use of large caliber weapons from interiors and reducing the weapon signature is to trade-off range performance. Current weapons are designed for ranges on an order of magnitude greater than those required in urban combat. Thus a corresponding reduction in backblast and signature may be possible while maintaining the essential delivery performance for fragmentation, HEAT, HEP, and other munitions not relying on kinetic energy for terminal effects. One approach is to design special short range performance rounds since (1) this would permit a full spectrum of tactical application and ranges, (2) the rounds could be selected to give optimal performance at the modes of the range distribution shown in Figure 23, (3) the lack of recoil of a recoilless weapon is essentially invariant to the propellant change, and (4) present recoilless weapons would need only an improved sighting system. Another approach is to adopt a bagged charge design such as with mortars and large caliber artillery rounds.

An attractive technique for allowing use from enclosures is the adoption of in-flight burns. Accuracy suffers from in-flight burns, but at city ranges this is essentially no problem.

A third method to allow firing from enclosures would be protective equipment for the operators. This equipment would include earplugs to prevent eardrum rupture, helmet and goggles to prevent

head and eye injuries from flying and falling debris, and possibly a gas mask to prevent poisoning from the noxious and highly concentrated exhaust gases. These items of equipment alone might permit firing from most rooms, although this should be carefully determined by graduated tests. It may be necessary to supplement the above items with some form of protection for the lungs which become vulnerable at higher blast pressures.

The cheapest and quickest method for allowing large caliber recoilless fire from buildings is simply to knock out interior walls and even floors until a sufficient area is cleared to allow safe firing. Structural members should probably be left intact, but plaster and other loose material should be removed from the area. The great disadvantage to this method is the time and manpower required.

The final method suggested for allowing fires from interiors, and the best method for reducing weapon signature, is the development of horizontal mortars transferring the recoil to the vertical structure of the building. It would be essential to provide for direct aimed fire at low angles of elevation and even depression. This would probably require a trigger mechanism. This horizontal mortar, designed for the reduced range requirements of city combat, will have significantly less weight and recoil than a comparable caliber conventional mortar. Thus an 81 mm mortar fired from the shoulder with the baseplate (or better, an extended leg apparatus) against the rear wall appears feasible. Other methods of recoil transfer would include brace and halter arrangements (see Figure 25).

(5) <u>System Recommendations</u> -

(i) Concepts of Employment - The concepts of employing the improved man-portable large caliber weapons are basically the same as with present weapons, except that maximum use of enclosures should be made for cover and concealment.

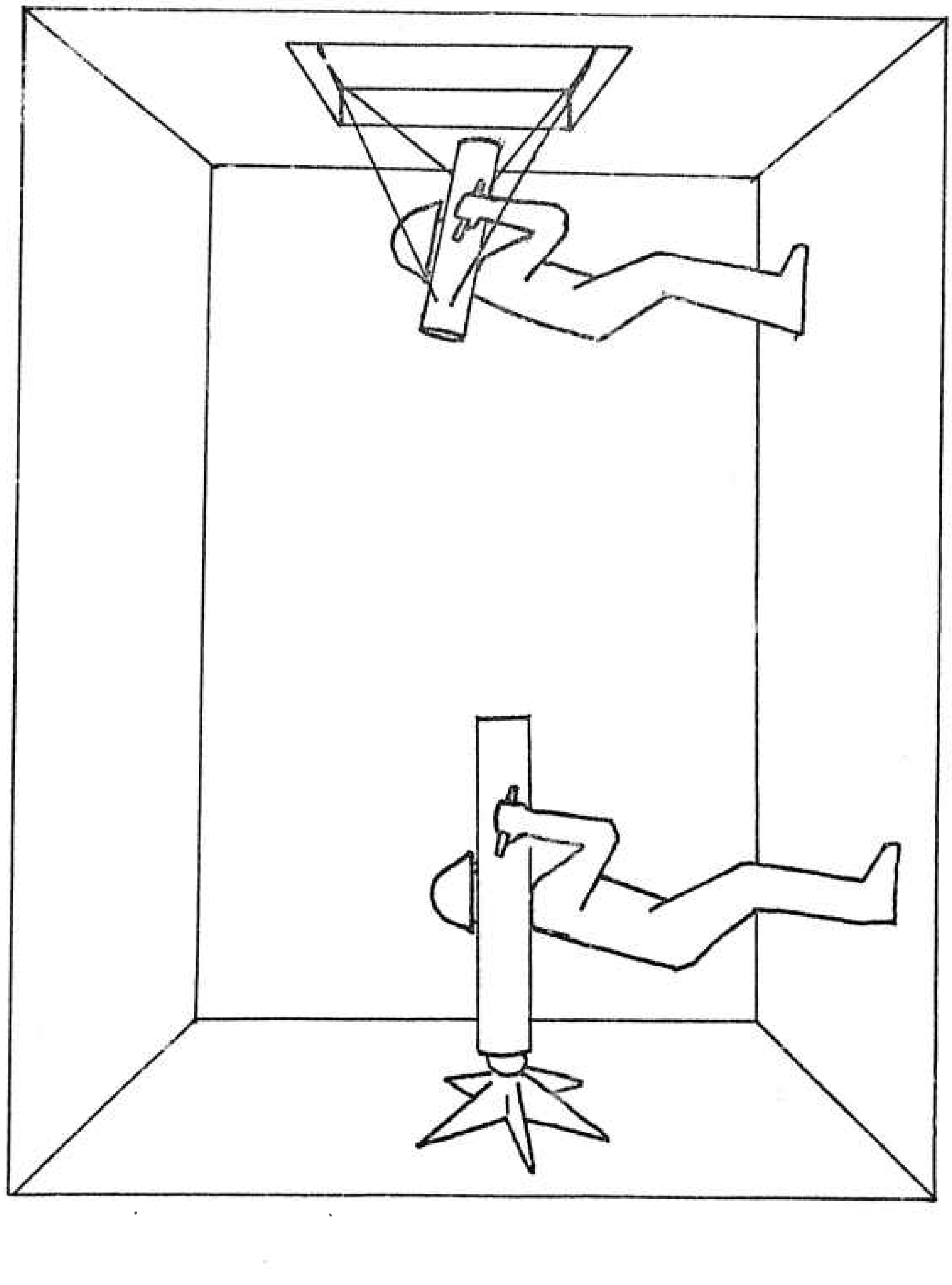


Figure 25: Horizontal Mortor Concept

(ii) Technical Feasibility - The modifications to current systems and new system concepts proposed above are within the state-of-the-art and entail no technological breakthrough. The approaches outlined take advantage of current engineering trade-offs available (that is, trade-offs with range performance) or propose to provide the required capability by a system specifically designed for the environment of urban combat. This is not meant to imply that there will not be some major redesign and engineering problems associated with the proposed modifications and system concepts. These are engineering problems whose solutions, however, appear amenable to current practice.

(iii) Pay-offs - A proper evaluation of pay-offs for the improved systems on the larger combat mission requires field exercises and (possibly) manual or computer gaming assessments. At this point it is possible only to say that, based on educated judgment, the capacity to fire from inside structures, especially with reduced signature, is well worth the anticipated increases in cost and reduction in range and accuracy.

(6) <u>Man-Portable Weapons -- Findings and Recommendations</u>

(i) The infantryman in a built-up area frequently needs to delivery relatively large pay-loads to close-in targets. Current U.S. weapon systems capability does not satisfy this requirement.

(i) Concept formulation efforts should be undertaken toward the needs for short range, large pay-load man-portable weapon systems along the lines developed in this study.

(ii) Present U.S. rockets and re-coilless weapons developed for land combat are of limited utility in urban areas. Due to the back-

(ii) In the highly structured urban "terrain" there are many features whose mass, structural strength, and geometric regularity can be

blast, they cannot be fired from enclosures without hazard to the operator, nearby friendly personnel, and the surrounding structure.

(iii) Present HEAT warheads, while effective in perforating urban structures, are inadequate in behind-the-wall effects. HEP warheads, presently not available for large caliber man-portable weapons, also have potential for improvement and use against urban structures.

exploited to absorb the recoil momentum of closed-breech weapons. Recoil transfer mechanism options should be examined for closed-breech weapons.

(iii) Testing and analysis of HEAT and HEP warheads should be conducted on selected structural targets to determine improved techniques of employment and to establish the defeat mechanism as a basis for design improvement. Improved warheads should be made available.

IV.3 Infantry Support Weapons

IV.3.1 Use of Artillery in Cities

(1) Current Capabilities - Indirect fire is the common mode of operation for using U.S. artillery in urban areas. The characteristics of the urban environment pose problems for this role of artillery. Indiscriminant use and the general nature of indirect fire usually cause a great deal of collateral damage and experience leaves room for doubt whether the benefits of indirect fire are greater than the disadvantages. The battles for Aachen in World War II and Hue during the Vietnam conflict are reasonably representative examples of the use of artillery in cities. Table 12 is a summary of the action in these two examples. In both cases the cities were heavily shelled -- creating extreme collateral damage to buildings, life supporting utilities, and homes. Again in both cases, the rubble produced by the bombardment provided cover for the defenders and acted as a barrier to the attackers. Table 1 presents the lessons learned from urban battles in general.

An extreme example is the battle for Leningrad. Figure 26 shows the number of rounds falling on the city by month.

In addition to the 45,000 rounds of artillery, the Germans dropped over 100,000 bombs (approximately 95 percent incendiary and 5 percent HE). The city's population was about 3,500,000 with about 200,000 fighting men at the time the seige began.

The figures below represent the total effectiveness in terms of casualties at Leningrad.

Average number killed/shell	= .02666
Average number wounded/shell	= .08260
Average number of casualties/shell	= .10920

The city was never taken. Further, during this period the Soviets managed to bring into the city during a five month period 360,900 tons

Table 12: Combat Experience Chart

	AACHEN 1944	HUE 1968
DEFENDING FORCE	5200	8500
LENGTH OF SIEGE (DAYS)	10	26
BOMBS DELIVERED ONTO CITY (TONS)	166	193
ARTILLERY ROUNDS FIRED ON CITY	26,000	65,000
LARGEST ENEMY WEAPON (DEFENSE)	150 MM	82 MM MORTAR
U.S. & FRIENDLY CASUALTIES (KIA, MIA)	84	594
DEFENDER CASUALTIES	1500 FATALITIES & MISSING 20,000 HOMELESS	2600-5000(?) KILLED 46,000 HOMELESS

Table 13: Lessons Learned: Artillery

STALINGRAD, WARSAW, CASSINO ETC.

- LONG RANGE ARTILLERY CAN <u>ASSIST</u> A DETERMINED DEFENDER BY IMPEDING ATTACKER (RUBBLE) MOBILITY AND PROVIDING DEFENDER CONCEALMENT AND PROTECTION
- DANGER OF FIRESTORMS IF INCENDIARY FOLLOWS HE BARRAGE ("VENTILATED" BUILDINGS)
- LARGE CALIBER DIRECT FIRE REDUCES STRONGPOINT BUILDINGS: YIELDS LESS COLLATERAL DAMAGE

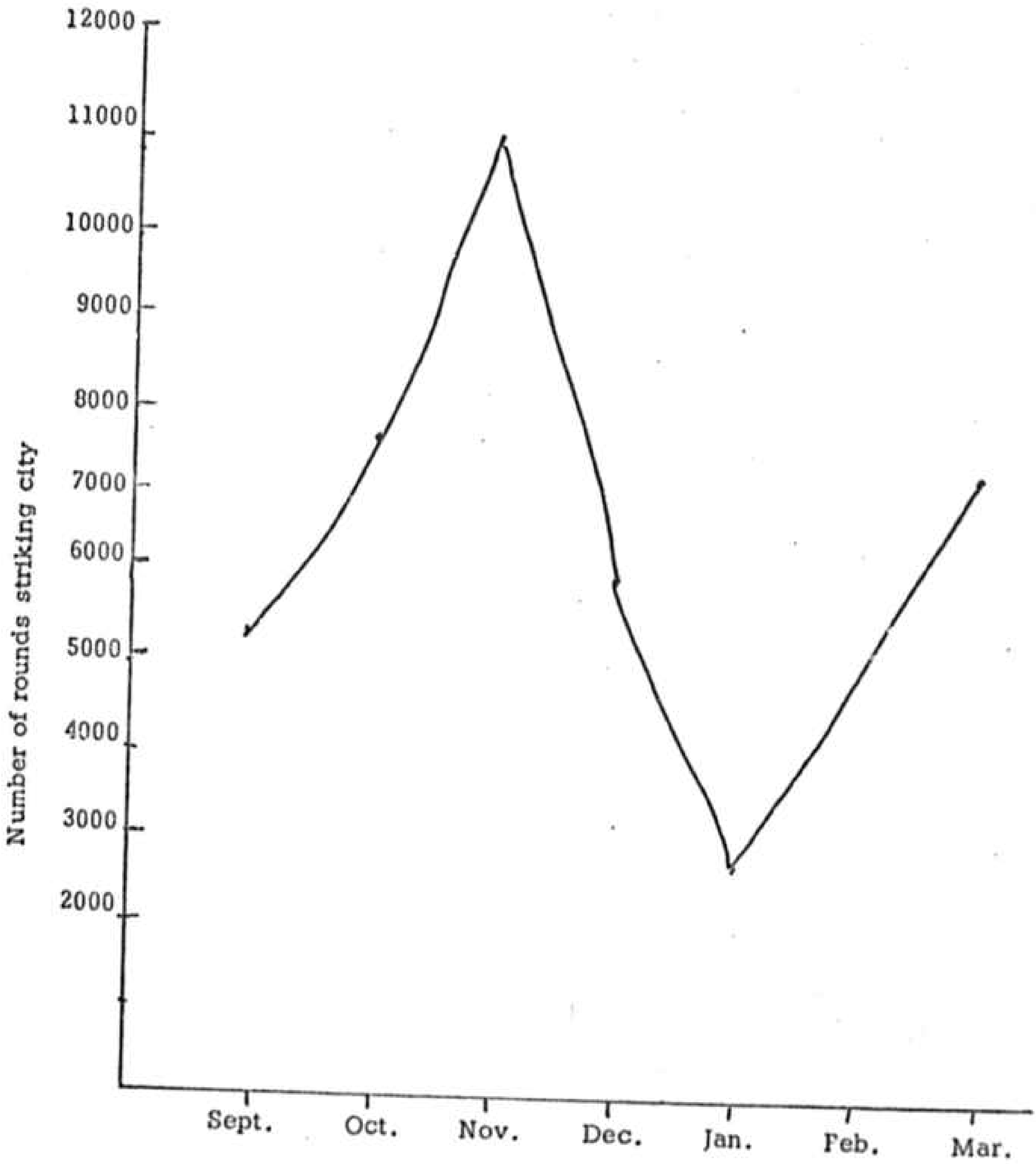


Figure 26. German Artillery Fire on Leningrad

of food and equipment -- more than 2000 tons per day. The waterworks was struck by 62 HE and 272 incendiary bombs plus a number of 155 mm artillery shells. There were 5609 water main cuts causing a 20 percent reduction in water supply.

Numerous cities around the world have citadels surrounded by thick walls and moats located in their central districts (St. Malo, Poznan, Manila, Hue). These have proven to be a particularly stubborn strong point for city invaders to overcome.

The citadel at Manila (16 feet high, 30 feet thick) was attacked during World War II by U.S. forces. It took 150 rounds of 8 in howitzer (HOW) indirect fire to make a breach using direct fire. The 155 mm HOW was fired at the wall from 800 yards and it took 150 rounds to make a 50-foot break at this range. Towards the end of this attack, it was found that unfuzed HE shells from 155s fired point-blank were useful in making fissures in the wall that could later be enlarged by delayed fuze HE rounds.

A small citadel at St. Malo was found to be relatively impervious to 3 in tank destroyer rounds and indirect 8 in shells. Eventually the 8 in HOW was used at point-blank range to make breaches.

The Soviet World War II assault on the Poznan citadel saw their tanks fail to penetrate the thick outer wall of this fortress. Even shells from 203 mm cannons fired from 300 meters had little effect. An attempt was made to plant enormous quantities of explosives under a piece of the wall where the point-blank artillery fire had made a small breach that was being widened by renewed 203 mm fire. The idea was to blow part of the citadel wall into the surrounding moat to allow tanks to cross over and plunge into the citadel. This too failed because the Sixty-Second Army did not have enough explosives available. Finally, a hole was

blasted through after two days of direct fire and flame throwers were used to encourage German surrenders.

(2) Functional Area Interface - There are several key areas in which the use of indirect fire has an impact on other functional areas. However, the magnitude of the impact is difficult to assess quantitatively. Population attitudes are extremely important both in the immediate sense directly after the city is won or lost and in the long range sense. For instance, urban guerilla actions can continue, especially with population support, for lengthy periods.

Another problem area has already been referred to with respect to Mobility: the problem of creating rubble barriers with the use of Firepower. Damage to structures can be reduced significantly if at some point the artillery support shifts from an indirect fire mode to a direct fire mode. Current U.S. doctrine on the use of artillery in the direct fire role is indefinite and should be reviewed. Historical experience supports the conclusion that the bulk of the work must be accomplished in the direct fire role. The weapons must be driven into the city to be effective.

In this connection, two problem areas must be addressed:

(a) Methods must be evolved for bringing in large caliber artillery and protecting it in the urban areas. These problems are similar for armor.

(b) Pieces must be positioned for area control and high points. Coverage of rivers, open areas, and rooftops can require unusually large angles of elevation and depression. New materiel concepts for accomplishing this task for artillery may be necessary. Since collateral damage may be increased by the general use of indirect firepower, discriminating use requires precision delivery which can be achieved by moving

within point-blank range for direct fire. This issue is discussed from a different point of view under smart weapons concepts.

The accumulation of management information is extremely important and perhaps indicates that Communication and Surveillance functions can be used in conjunction with the FDC to provide an improved data base with such information as friendly unit location, strongpoints data (including not only locations but relative strengths and the best method for their reduction), and locations of neutrals. The TACFIRE system in its present form will fill some of these information needs but should be reviewed during the early stages of development and production to insure that the urban commanders' needs are considered.

(3) Concepts of Employment - The current use of artillery in built-up areas can be expressed in terms of a direct comparison with Soviet doctrine. U.S. doctrine is summarized in Table 14. Soviet doctrine is summarized in Figure 27. The key differences are shown in Table 15. These differences involve the use of field pieces, either towed or self-propelled, in the direct fire role and the protection of these pieces in close combat.

Analysis of several scenario battles supported the use of direct fire artillery in urban areas. Infantry personnel are in constant need of heavy firepower to support their operations. Two needs stand out: (1) the need to breach hastily erected barricades and (2) the need to reduce resistance within building strongpoints. The HE, HEP, and inert rounds appear to be well suited to these tasks.

(4) Improved Concepts and New System Candidates - The two primary conclusions of this analysis are: (1) when engaging the strongpoints artillery must be used in the direct fire role, and (2) it is necessary to develop an improved information system for urban battle commanders.

Table 14: U.S. - Artillery Doctrine* for City Combat

<u>MISSION</u> -

- SUPPORT ATTACKING GROUND FORCES
- DESTROY HEAVY FORTIFICATIONS & BUILDINGS
- NEUTRALIZE ENEMY ON TOP FLOORS & ROOFTOPS

<u>SUGGESTED WEAPONS/ROLES</u> -

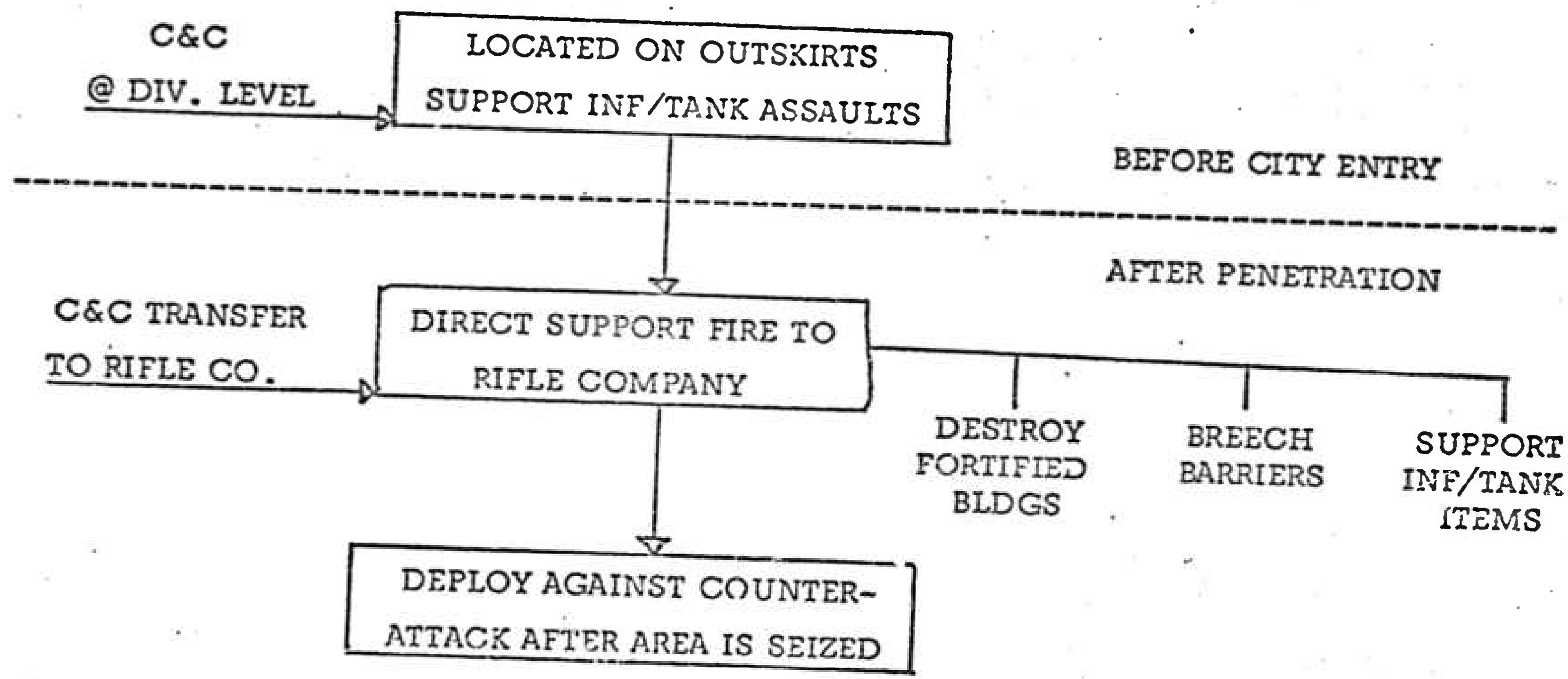
- 155 MM SP — DESTROY BUNKERS & CONCRETE BUILDINGS (36" CONCRETE @ 2700 M.)
- 8 IN HOW — DESTROY CONCRETE BUILDINGS & DEFENDING TROOPS (56" CONCRETE)

* FM31-50

MISSION -

- DESTROY FORTIFIED BUILDINGS
- BREECH BARRICADES & OBSTACLES FOR VEHICLE & TROOP PASSAGE
- SUPPORT INFANTRY & TANK ADVANCE
- COUNTER COUNTERATTACKS

ROLES -



SOURCE: "MILITARY HERALD" DEC 1961
(A SOVIET DEFENSE PUBLICATION IN TRANSLATION)

Figure 27: Soviet - Artillery Doctrine for City Combat

Table 15: Key Differences: U.S. & Soviet Doctrines

US	USSR
• PREPARATORY FIRES ONLY IF NEEDED	• QUICK, INTENSE PREPARATORY FIRES ALWAYS
• DISCOURAGES ARTILLERY ENTRY INTO CITY; MASSED FIRE WHEN NEEDED	• USES ARTILLERY DIRECT FIRE ON STRONG POINTS
	• EMPHASIZES CHEMICAL WARHEADS
	• DEALS WITH ARTILLERY VULNERABILITY IN CLOSE COMBAT

With regard to the first conclusion, other military forces have adopted operating doctrine which differs from the U.S. expressed doctrine. Indeed, in actual practice U.S. commanders depart from U.S. expressed doctrine. Many times, U.S. commanders have ordered artillery units to perform in the direct fire role, usually after a frustrating experience attempting to follow expressed doctrine. Consequently, our doctrine should be reviewed to insure its adequacy. If doctrine is to be changed, security measures and methods will have to be implemented to provide protection for crews and weapons.

With regard to the second conclusion, the needs of the urban commander should be reviewed with respect to the capabilities of the FDC and future fire control systems. The close proximity of opposing forces and the reduced reaction time require that, the commander have quick access to up-to-the-minute information concerning troop strengths on both sides, casualty rates, suspected strongpoints, disposition of neutrals, safe access routes or supply channels, locations of reserve and support units, ammunition consumption and resupply rates, types of construction or fortification, and the precise location of friendly troops. The latter need is particularly important since support fire will often be needed for targets that are within tens of meters of friendly troops.

The ability to provide for these needs appears to be within the capability of improved FDC systems now under development. These new systems should be assessed to insure that they are compatible with urban combat information needs. New sensors and communications may be required to provide the necessary information. Adaptation of a system similar to Digimap is possible. This could provide the FDC and the commanders with real time position data for major units and weapons. Weapons that are outside each other's field of view but which may be just around the corner from each other can work effectively as a coordinated

team with the help of real time position data. Prototype Digimap systems are being used by civil agencies. Their use with automatic data processing (ADP) systems appears to be technically feasible.

Finally, the introduction of the direct fire role for artillery may require a review of our current and developmental munitions. New munitions with improved capability against solid structures are needed. At the very least, the production of these munitions may have to be increased to reflect the increased probability of urban combat.

(5) Use of Artillery in Cities - Findings and Recommendations

(i) U.S. doctrine for the employment of artillery against urban targets lack specificity regarding the use of artillery in the direct fire role and does not address the counterproductive effects generally produced for the attacker by the employment of extensive indirect artillery fire.

(i) Current doctrine for using artillery against cities should be reviewed and modifications considered with respect to employment in the direct fire mode.

(ii) The availability of up-to-date information on the location and disposition of friendly and enemy forces, civilian populations, and key installations is of critical significance in the restricted confines of urban combat. The Fire Direction Center and Fire Support Coordination Center may become a valuable data storage and processing source for this information requirement.

(ii) The capacity of the Fire Direction and Fire Support Coordination Centers, especially new systems such as TACFIRE, should be analyzed with respect to their ability to meet the commander's need for timely and detailed information on force dispositions and key structural features in combat in built-up areas.

(iii) Current HE and HEP rounds are not designed for use against urban structures.

(iii) Testing is required to determine current munitions effectiveness against selected classes of structures. New concepts of employment should be developed based on the test results. Warhead design alternatives should be examined with respect to urban combat requirements.

IV.3.2 Aerial Fire Support

(1) Analysis of Current Capability - In this section consideration is given to delivery of firepower from three types of aerial platforms: helicopter gunships, tactical fighter bombers, and remotely piloted vehicles. These delivery systems are conveniently analyzed together since they share essentially common missions and problems.

(i) Helicopter - The development of the helicopter gunship during the Vietnam years climaxed with the Huey Cobra carrying TOW and a 7.62 mm minigun. The 7.62 mm minigun is not completely suitable for urban combat due to its inability to penetrate structures, although it will suppress fires and kill through windows. The TOW has proven extremely effective against tanks, but it is very expensive and can not be used efficiently at very short ranges. The 40 mm rapid fire grenade launcher has seen use on helicopters in Vietnam, but would be of little use in built-up areas. Of greater use in urban combat would be the 2.75 in rocket packs or 20 mm Vulcan machine gun which provide good suppression and better penetration than 7.62 mm weapons.

Current Army helicopters have several severe limitations for operations in cities, including vulnerability to small arms and sniper fire, poor lateral maneuverability, and a lack of equipment for night operations.

The Advanced Attack Helicopter (AAH) currently under development for the Army, will alleviate these problems to some degree. It will have increased maneuverability for survival, including side-slip turns and tight turns at high speed. It will be armored to withstand a 12.7 mm projectile. It will carry a radar warning device as well as night vision equipment. The AAH will be armed with TOW's initially and later with the heliborne laser fire-and-forget missile (HELLFIRE) now under development. It will carry a 30 mm turret cannon, providing significantly increased structure penetration. Additional armament will include 2.75 in rockets.

(ii) Fighter bombers - - Current U.S. aircraft are capable of delivering heavy ordnance with extremely good accuracy. Advanced A-7 aircraft have delivered 250-300 lb bombs with better than 10 meter CEP accuracy under controlled tests of daylight bombing, giving better than 20 meter CEP at typical release slant ranges. The A-6 and F-111 provide all weather delivery of ordnance with CEPs on the order of 200 meters. Using forward looking infra red (FLIR) devices the built-up area can be seen with remarkable clarity at night, and WP designator flares provide good reference markers even in bad weather.

The standard inventory of bombs from 250 to 2000 lbs gives good penetration of buildings with delay fuzing. Also, general purpose (GP) bombs of 750 to 3000 lbs can be delivered. Snakeye (drag retarded) 250 and 500 lbs bombs permit low altitude release. Also available are precision guided munitions (PGMs) using laser designation and TV contrast-lock techniques. These munitions are discussed elsewhere in this report.

The above aircraft can also carry varieties of missile (Bull-pup, Strike), rockets (2.75 in) and cannon (20 mm).

(2) Environmental Characteristics - The built-up area environment has important implications for the delivery of weapons. Perhaps the most important is the shrinking of the battlefield. In the vast majority of cases friendly troops will be in the building adjacent to the target (that is, within 30-50 meters), making a 200 meter CEP unacceptable and even a 20 meter CEP hazardous.

The typical urban combat situation has an exceptional number of structural and orientation implications for weapons size and delivery as suggested in the following diagram, Figure 28.

The enemy will usually be located on the lower floors of a strong building and oriented toward the friendly forces. Hits on the roof with rockets, missiles, or even light bombs may be ineffective. It is best to hit the lower floors at a good incidence angle to prevent riccochet — but this is not easy. Heavy bombs are more effective but may cause excessive collateral damage, rubble, and risk to friendly forces.

The masking of structures denies the best angles of attack for bombs, rockets, and other projectiles, even the guided ones available. In order to hit the face of an enemy strongpoint at the ideal perpendicular angle it is necessary for the munition to make a very sharp turn prior to impact. Current weapons are incapable of this.

(3) Functional Area Interface -

(i) Helicopters - Aerial artillery requires the standard artillery communications net. The pilot needs excellent "eyes" both in his own vision and auxiliary equipment in order to locate targets previously designated with smoke, flares, or white phosphorus grenades.

(ii) Fighter bombers - Targets for fighter bombers will be designated by a forward air controller (FAC) attached to the ground forces and operating from a suitable aircraft or vantage point. The target will be designated much as by the FO for aerial artillery. Excellent communications are required.

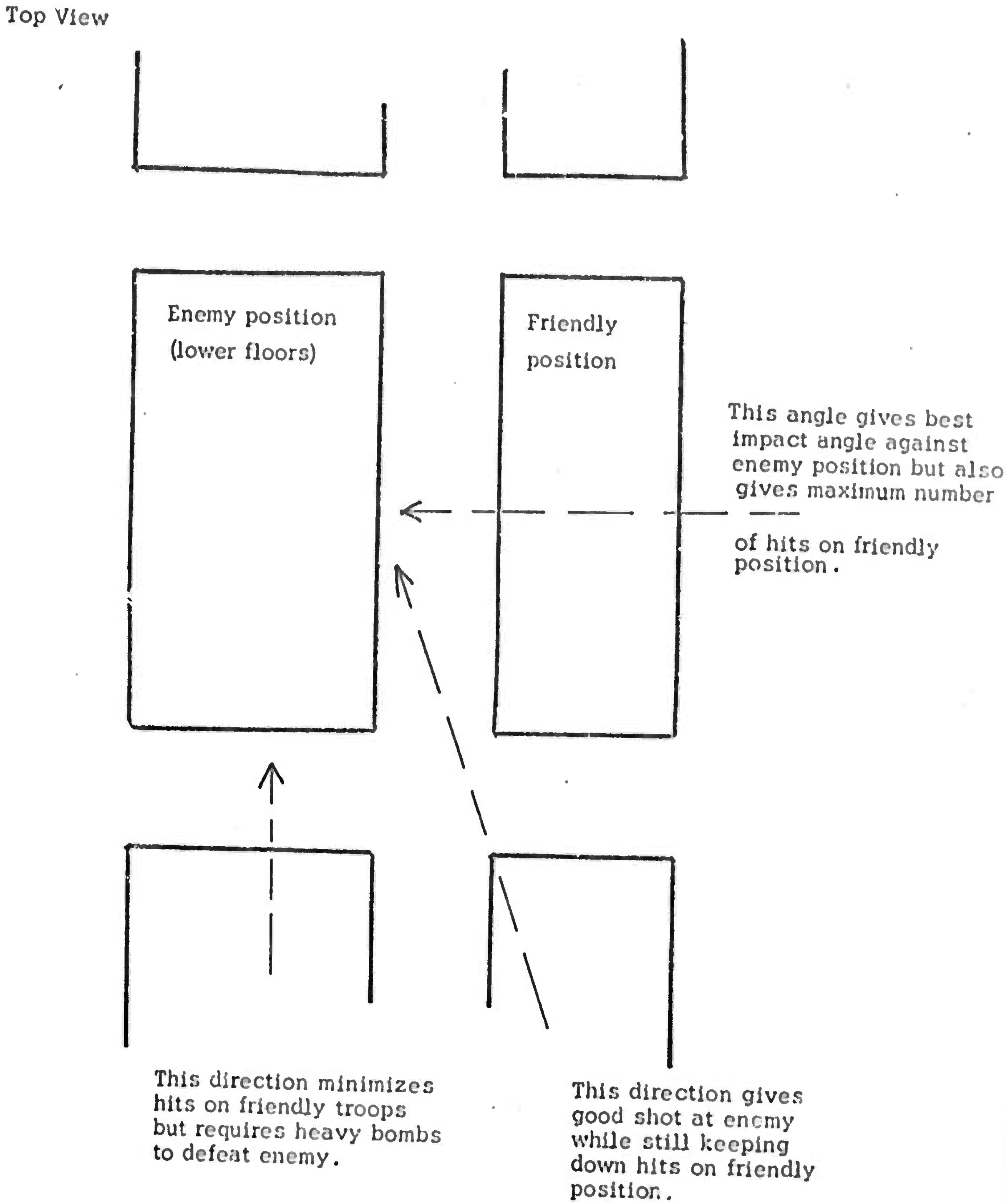


Figure 28: Delivery Problems in Urban Terrain

(iii) Remotely Piloted Vehicles (RPVs) - These will require excellent communication in order that they can be flown via TV link from a distance control station. Considering line-of-sight problems and ambient electromagnetic radiation, not to mention enemy electronic coutermeasures (ECM), the communication task will be formidable.

(4) Development of New System Candidates -

(i) Concepts of Employment for Current Systems -

a. Helicopters. Aerial artillery in cities is essentially the same as in the field, with perhaps some additional information transmission to capitalize on city landmarks and street layout.

b. Fighter bombers. Employment is essentially the same as in the field, with increase in accuracy requirements.

c. Remotely-Piloted Vehicles. No doctrine exists.

(ii) Current Combat Task Capabilities -

a. Helicopters. The potential is largely untested. Gunships saw so little use in urban areas of Vietnam as to lend meager support to speculation as to effectiveness or vulnerability. The preponderance of opinion is that the gunship is too expensive and too vulnerable to be used extensively. Losses at Hue support this. But, against key enemy targets high attrition may be acceptable since the battle may hinge on the target's timely destruction.

b. Fighter bombers. There is no question that fighter bombers can quickly destroy enemy strongpoints. The question is whether collateral damage and our force and civilian casualties can be tolerated. The answer varies with the import and sensitivity of the situation, but it is suggested that the answer

will usually rule out all but precision guided munitions. One of the Hue commanders said he would use a 750 lb warhead delivered with 10 meter CEP and accept resultant own-force casualties, but his opinion may not be shared by other commanders.

(iii) Search for New Systems -

a. Helicopters. Improved design requirements for helicopters for city combat are being developed by CALSPAN. Several areas of armament deserve attention. First is a requirement for side-firing weapons of all calibers. The importance of this was recognized as far back as the Algerian conflict* but is particularly important in built-up areas where the helicopter must perform dangerous and time consuming acrobatics in order to obtain a good axial line on the target. It is highly desirable to give the gunship the capacity for large caliber fire at the target during fly-by.

A second highly desirable system for helicopters in any environment would be a hostile fire detector and locator coupled with a suppressive return fire weapon. Such a system would be extremely expensive, but considering the cost of a gunship it may well be justified.

b. Fighter bombers. Extreme accuracy delivery of heavy ordnance is almost imperative in city combat. A CEP

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* Symposium of the Role of Airpower in Counterinsurgency and Unconventional Warfare: The Algerian War. The RAND Corp., Santa Monica, Calif., Memorandum RM-3653-PR, July 1963.

of less than 20 meters is required and 10 meters desired. It is doubtful whether 10 meter accuracy can ever be consistently achieved with iron bombs in actual combat using the present flight profiles imperative for aircraft survival. Ballistic dispersion itself is on the order of 10 meter CEP. Therefore, major emphasis must be placed on precision guided munitions. These munitions should be designed to minimize riccochet and maximize penetration.

c. Remotely Piloted Vehicles. It is desirable to provide these weapons with a high degree of maneuverability.

(5) Preliminary Design Concepts of New Systems -

(1) Helicopter - Side-firing large caliber weapons for helicopters are almost necessarily recoilless. Ground tests firings at Frankford Arsenal of a 106 mm RR from a helicopter indicated that the backblast could cause structural damage to the aircraft. There is reason to believe that this problem would be alleviated in actual flight since (1) there would be no ground reflection, and (2) the airframe would be free to roll with the punch. In any case, there are design modifications which should produce an acceptable weapon. These include: (1) accepting some recoil, (2) directing backblast slightly downward, (3) employing a muzzle brake, (4) using externally burning rockets. In city combat the side fires from a helicopter will be almost exclusively at short ranges (less than 100 meters); therefore, the inaccuracy inherent in externally burning rockets becomes of small importance.

The automatic hostile-fire detector with return suppressive fire could be constructed on one of two design concepts. The first concept consists of four elements: (1) a near miss or hit detector, (2) a thermal gun flash locator, (3) a fire control system, and (4) a weapon. These

components will be discussed more fully in the next section. It should be emphasized that this system is defensive, not offensive. There is no requirement to kill the firer, only to suppress his fires or obscure his vision.

The second concept requires a sophisticated doppler radar system capable of determining the projectile trajectory. This data would feed a computer fire control system which would, in concert with a second radar, track back along the trajectory to the intercept with a building — the apparent hostile location — and aim and fire the weapons at that target.

(ii) Fighter bombers - Precision guided munitions are discussed in detail elsewhere in this report.

(iii) Remotely Piloted Vehicles - In order to achieve increased maneuverability RPVs should be designed with large wing areas. Also, autogyro and helicopter designs should be considered. Precision guidance of an RPV into a target, using sharp turns, would be greatly enhanced by the use of binoculars TV control so that the operator could see in three dimensions.

(6) <u>New System Concepts</u> -

(i) Concepts of Employment -

a. Helicopters. Aerial artillery would be used quite differently given side-firing large caliber weapons. The gunship would employ a fly-by technique, passing the enemy emplacement at high speed and loosing the large caliber munition at point-blank range. The target must be well designated, either be description ("third floor, second window from the north end") or by tracers or smoke. Smoke would be ideal if confined to the target since it gives the gunship protection by obscuration.

Gunships would escort airmobile forces essentially according to current doctrine. The automatic detector/suppressor would call for formation flying and weapon stops to prevent firing on accompanying aircraft.

b. Fighter-bombers. The only change in employment envisioned is the use of RPVs for target designation. The RPV would be controlled by an FAC unit or possibly be attached to field artillery units.

c. Remotely Piloted Vehicles. The most logical attachment of RPVs is to the field artillery. In addition to target location the FO would indicate the proximity of friendly forces and civilians, the location of nearby buildings, and give a verbal assessment of the masking problem. Based on this information, the artillery officer would decide whether to use conventional artillery, cannon launched guided projectiles (CLGPs), or RPVs. If an RPV were selected, the operator should be put in contact with the FO in order to determine attack profile and coordinate target designation.

(ii) Technical Feasibility -

a. Helicopters. The side-firing large caliber weapon is well within the state-of-the-art.

The hostile-fire detector is currently available, but the target locator is probably near the technology threshold for thermal imaging, and somewhat beyond for doppler radar. The fire control system is within the state-of-the-art. The high rate of fire 7.62 mm machine gun is a suitable response weapon now available. Shotgun or larger caliber weapons could

be easily designed or adapted. It should be mentioned that the proposed radar/weapon system is not unlike the Navy CIWS (Close-In Weapon System) which is operational.

b. Fighter bombers. The state-of-the-art for PGMs is advancing rapidly, as discussed elsewhere in this report.

c. Remotely Piloted Vehicles. These are within the state-of-the-art.

(iii) Pay-offs -

a. Helicopters. There is a general consensus that the gunship will not prove a cost-effective alternative to field artillery, tactical air, or armor in destroying enemy strongpoints if the measure of effectiveness is dollar cost. However, if time to neutralize the strongpoint is considered along with reduction of collateral damage and friendly casualties, the issue is not so clear cut. It seems safe to say that, considering those additional factors, there will be numerous situations in which gunships are the weapon system of choice despite their cost.

As an airmobile escort, the gunship has no competition; so the question is whether to do with or without. At this juncture it seems that if the mission is important enough to warrant airmobile assault, it is important enough to justify gunship escort.

As to production cost of the proposed new systems, the side-firing large caliber weapon will be of very modest cost relative to the entire weapon platform. The cost of the automatic suppressive fire system will be high.

The thermal gun flash detector has been price estimated at $100,000, suggesting that the entire system would cost about as much as the helicopter. Even so, the system would be cost-effective if it significantly reduced gunship losses. And advancing technology should bring cost down.

b. Fighter bombers. The costs of PGMs are discussed elsewhere in this report. The cost of current fighter bombers is in the $2-4 million range and the next generation will treble these costs. So the system cannot be expended lightly. But currently it is the only weapon system capable of delivering heavy ordnance on a first round basis against enemy strongpoints.

c. Remotely Piloted Vehicles. The least expensive now in development cost $10,000 and there is reason to believe that useful weapon delivering RPVs will cost this much and up. Thus the number of situations for which an RPV would be selected over artillery or gunships is limited.

(7) Aerial Fire Support -- Findings and Recommendations

(i) Helicopter gunship fire support has high payoff potential for prompt attack on defense strongpoints and interdiction of reinforcement elements in many urban combat situations despite the probable high cost of attrition.

(i) Exploratory Development should be undertaken in the areas of side-f' ing or flexibly mounted large caliber weapons, application of PGMs, and application of protective armor in the employment of helicopter fire support to ground units in urban combat situations. Concurrently, more explicit doctrine and tactics should be developed.

(ii) Fighter-bombers will continue to have a role in many urban battles, especially with the advent of Precision Guided Munitions. However, due to the close ranges of engagement, the accuracy of munitions delivered by Fighter-bombers will remain only marginally acceptable at best, and the cost of such operations would be extremely high in the sophisticated anti-aircraft environment likely to be found in urban combat.

(ii) Fighter-bombers should continue to be considered as primary means of delivering munition to targets in an urban environment, but the limitations of this kind of aerial fire support should be more fully recognized than in the past. The application of air-launched PGMs in the built-up environment requires more detailed analysis.

(iii) Except for the special case of a crucial threat, it is difficult to see Remotely Piloted Vehicles (RPVs) as aerial weapon delivery systems in urban combat. However, in the roles of target acquisition, forward designator/controller, and damage assessment, the RPV has distinct promise.

(iii) The progress of RPV development should be monitored for potential application for target acquisition and PGM designator roles.

IV.3.3 Use of Armor in Cities

(1) Current Capabilities - Analysis of the Technical Problem Resumes in detail confirms the lessons of actual combat experience. Armor is frequently sent into urban areas not because it is a good city fighting weapon but because there is an overriding need for a protected mobile firepower system. It turns out that tanks and, to a limited extent, self-propelled artillery are the only systems that provide this capability. The need for protected systems that have the ability to fire large caliber rounds should not be surprising since other sections of the MOBA study have come up with these needs also.

Tanks have been used extensively by U.S. forces when engaged in urban operations. Even with the exclusion of World War II, tanks have seen action on the streets of Seoul and on Highway 1 in Hue. In Seoul the tanks were mainly employed to breach 6-foot high North Korean barricades to allow U.S. Marine elements to advance along streets and to search and clear the adjacent buildings. In Hue the tanks were used to advance on enemy strongpoints. Since only a few tanks were actually used in the Battle of Hue, their effect was not decisive. However, battalion commanders felt that the tanks were not nearly as useful in the city as they were ~~in open combat~~. The chief reasons for this were canalized routes, obstacles, and the necessity for the tank to travel in the city buttoned up to avoid enemy small arms fire. The mobility problem is one that will be addressed by CALSPAN, Inc. in their final report. However, there seems to be little possibility of improving tank mobility in urban area by advanced technology. More attention to tank tactics in cities may be the area which will yield improved force capability. While the Armor School has given consideration to tanks in cities, these tend to concentrate on the protection of the tank from the many possible urban threats. There appears to be little attention paid to the proper deployment and use of tank companies in cities. This lack

of attention is by no means a universal characteristic: discussions with the Israeli General who took Jerusalem in 1967 reveal that they have given this problem much thought and consideration.

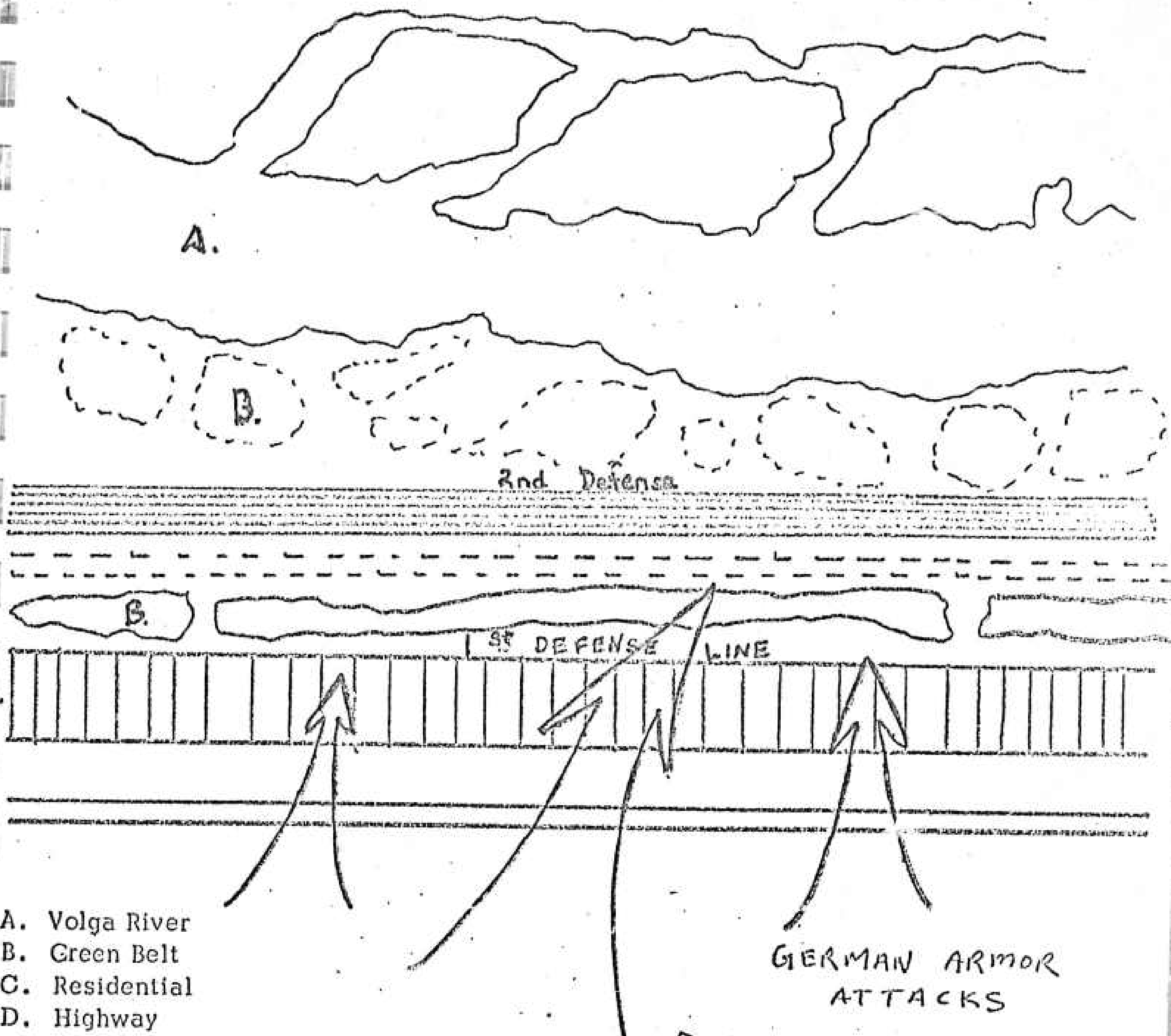
Almost everything that has been researched on armor indicates that tanks are designed exclusively for combat in open areas. While urban considerations should not dominate research with respect to armor, it should at least be considered.

(2) Functional Area Interface - Our consideration of armor in built-up areas has led us to the examination of the effect of urban morphology on tactical employment. This is an area that has received little attention elsewhere. It is quite possible that these considerations have been responsible for the success or failure of armor employment in past operations. For example, the city of Stalingrad was designed as a linear urban area on the banks of a river. As shown in Figure 29, the German armor attack had to assault the industrial section from the open; while in the built-up section of the city, command and control became difficult because of the natural separation by the structures imposed on the tanks. Even when this area was secured, the operation had to be repeated -- crossing the green belt in order to assault the second line of defense in the residential section. Interviews with field commanders and military historians confirm that armored units are vulnerable when approaching a line of buildings from an open area. For the city of Stalingrad, a linear city by classification, this type of armored assault had to take place twice. Since this type of operation frequently occurs in mid to high intensity combat, it should be considered from the viewpoint of this and other urban morphologies. Current contract work did not call for such an attempt at considering armor tactics in detail but the problem should be addressed. It is also of interest from the antitank perspective. This issue is important for the best placement of limited amounts of antitank fire.

Figure 2[illegible].

LINEAR CITY PLAN FOR STALINGRAD

By N.A. Milyutin, 1930



A. Volga River
B. Green Belt
C. Residential
D. Highway
E. Industrial
F. Railroad

(3) <u>Concepts of Employment</u> - An interview with a Vietnam veteran who was a tank crew member typifies the problem that was uncovered in this analysis. The soldier mentioned that he was repeatedly told not to enter cities, towns, or villages in the tank. These areas were traps for tanks. He concluded his remarks with the statement that they were always ordered in anyway. The analysis of historical events supports this tanker's observation. U.S. armor officers are taught that built-up areas are death traps for armor, but in real life the armor must move into the city to provide the armor-protected direct fire that is needed. Future battles are not likely to differ greatly from past battles in this respect. Consequently, techniques for the optimum use of armor in cities should be established. The individual problems that should be analyzed are discussed below.

(i) Methods of Entry and Movement - In each of the problem situations analyzed, armor moved into the city in a column, usually accompanied by infantry mounted in armored personnel carriers. When trouble occurred, the infantry dismounted and assisted the armor in engaging the enemy. Usually, the mission of the column was a relief action. In attempting to reach the beleaguered friendly forces, the column was trapped or ambushed in a city canyon. Obviously, methods of entry into a city are very important, and more explicit doctrine options prescribing entry methods would be useful to Armor officers. Some of the factors that should be analyzed are the effects of speed, evasive maneuver, spacing between tanks, and simultaneous multistreet entry. It can be seen that using the latter technique, the loss of a friendly tank becomes an independent event since other tanks are not blocked or channeled by the loss of a lead vehicle. High speed reduces exposure time. Simultaneous entry through several streets tends to confuse the enemy -- the tank sounds will be more difficult to localize. Rendezvous

techniques to establish a base of operations should be analyzed. Perhaps tanks should penetrate buildings for temporary cover at strong points until infantry can dismount and secure the area. Entry at night or under smoke cover appears to be another important area for consideration. Techniques for quick demolition or penetration of barricades should be reviewed. The need for coordination is extremely important, especially with limited visibility. The commander should know the precise location of each component unit in order to conduct the battle efficiently. In all, the problem analysis has indicated that much work should be accomplished in methods of entry and movement in cities.

(ii) Infantry support - Analysis of historical urban actions shows that the infantryman is less effective when heavy weapons are not available to provide supporting fire. Larger caliber weapons in direct fire are very useful in reducing strongpoints and providing covering fire. Conversely, the historical analysis shows that heavy weapons cannot easily fight and survive in built-up areas. Dismounted troops are needed to secure the armor so that they can remain in position and contribute to the firefight. Methods for coordinating the tank-infantry security team operation should be evaluated. The questions to be answered include: What are the infantry requirements for area security? Where should they be stationed? What special equipment and weapons do they need? What should be the basic load of the tank? (HEP is needed for strongpoint reduction, armor piercing or HEAT is needed to counter the threat of enemy armor, and HE and canister may be necessary for the antitank weapon threat.) How should tanks deploy to cover each other and support the fighting?

(iii) Vulnerability - The analysis highlighted several shortcomings with present vehicles which were designed for use on the battlefield. Vulnerability to close range attacks with shaped charge projectiles (LAW, 90 mm RR) and with Molotov cocktails are two such problems. The channelized movement caused by buildings further exposes combat vehicles to such threats. Angle of fire limitations in elevation and depression of turret mounted weapons is another problem.

(iv) Lethality of Current Firepower - There are many situations in which the lethality of current firepower causes many injuries to neutral or friendly personnel who cannot escape the battle area or who are being held hostage by hostile forces. There are other situations in which crowd control means are needed, but only firepower is available. These situations indicate that alternate less-lethal weapons and munitions are useful.

(v) Suppressive Fire Requirements - In almost every movement or attack situation, the attacker must contend with high casualty producing fire from protected defenders. In many cases, enemy personnel are able to hold up vastly superior forces for considerable times, often delaying time-critical missions. The ability to neutralize snipers effectively is a significant problem area.

(vi) Requirement for Cover and Concealment - Most advantages accrue to the defender in the city. He can choose the place to fight and has the advantage of cover and concealment. The attacking or maneuvering force requires methods for countering such cover or for providing their own cover to equalize advantages.

(vii) Antitank Measures in Streetfighting - The following measures have been employed when the defender did not possess AT weapons.

Molotov cocktails thrown from roofs of buildings down onto the tank. The gun elevation of the tank was usually incapable of countering such a threat. Snipers would pick off the tank crew as they emerged.

In Budapest "obvious" snipers would appear in a window located on a side street that was a dead end. If the tank went after this bait, it would have to enter the narrow side street and put itself in a very vulnerable position, being unable to turn around rapidly. Molotov

cocktails would then be used. About 80 Soviet tanks were killed in Budapest out of 300 committed.

Numerous ruses have been used to keep tanks out of certain city sectors:

- Lengths of pavement were painted with white stripes and signs posted "Beware of Mines."
- A clothes line stretched across a street with beer bottles tied to it scared off tanks.
- Soup plates turned down to simulate mines were used to force tanks closer to building by placing them in the middle of the wide avenues in Budapest; thus making the tanks more vulnerable to petrol bombs.

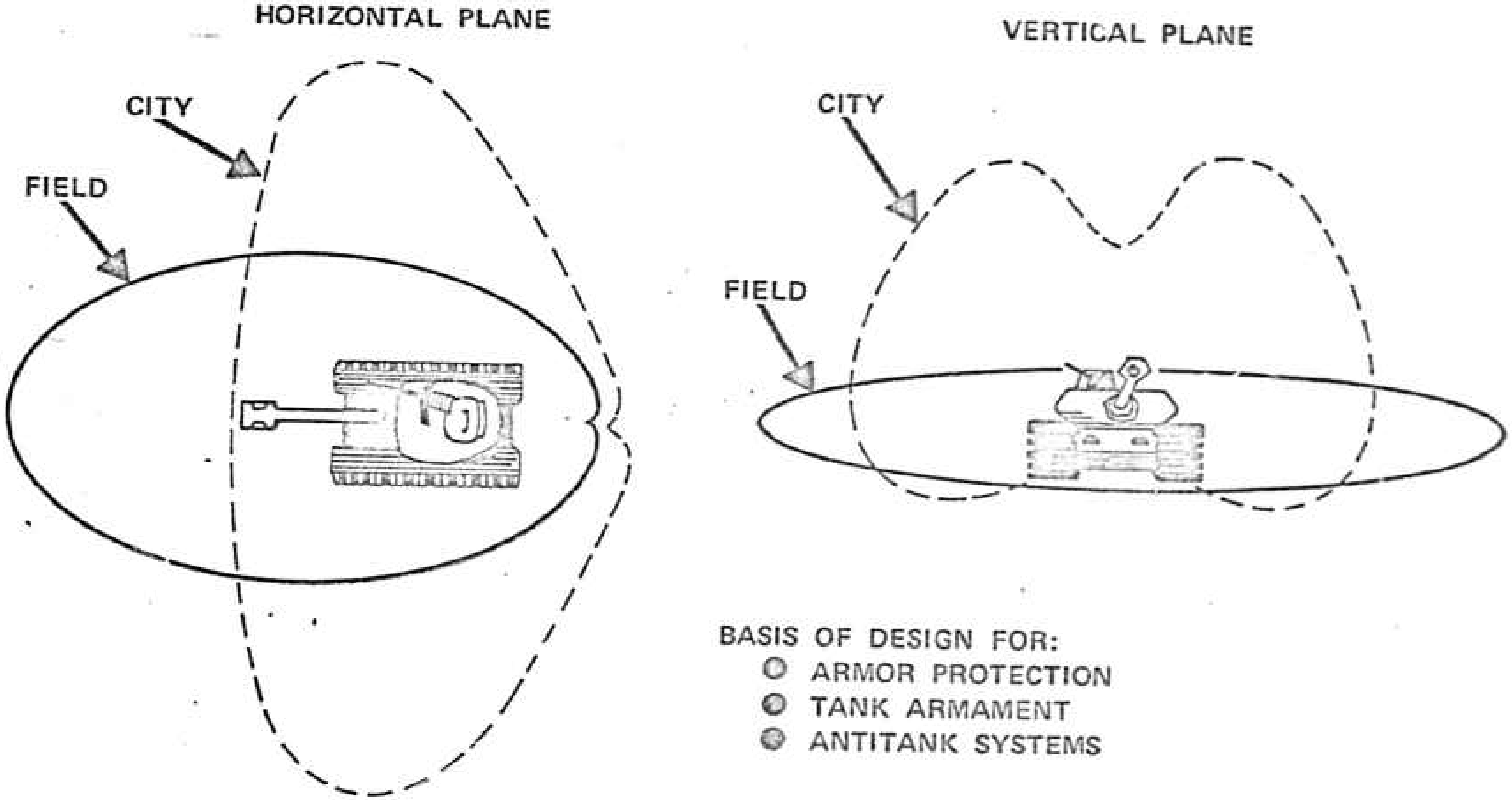
Figure 30 shows a frequency distribution of angle of attack against armor. In cities most attacks originate from the flanks rather than the front in the horizontal plane. In the vertical, attacks tend to come from elevated positions in nearby buildings rather than from ground level. Armor thickness on tank hulls and turrets is currently designed to provide protection against the field threat.

(4) Development of New System Candidates - The chief findings with respect to hardware improvements from the study are the need for equipment to dispense smoke from tanks and the need for a protective canopy for the tank. These concept items appear to be the most promising immediate improvements to the use of armor in built-up areas.

(i) Smoke Dispensers for Tanks - The use of smoke in combat to obscure, conceal, and blind is an integral part of combat in open areas. However, in urban combat it is an even more useful technique. The main reason for using smoke is to protect the infantry that accompany the tank if the team comes under hostile fire and to provide some concealment while crossing open areas. For example, in the Skoda scenario it becomes necessary for U.S. forces to advance into

Figure 30: **ATTACK ON ARMOR**

FREQUENCY DISTRIBUTION OF ANGLE OF ATTACK



BASIS OF DESIGN FOR:
- ARMOR PROTECTION
- TANK ARMAMENT
- ANTITANK SYSTEMS

unfriendly urban regions characterized by many narrow twisted streets. Smoke dispensing systems on the tank hull controlled from inside would allow the infantry-tank team to quickly conceal themselves from enemy fire. The probable type of enemy fire to be expected will consist of AT weapons fired at the tank and small arms fire directed at the infantry. It must be pointed out, however, that AT rounds striking the tank but not penetrating it are a major threat to the nearby infantry. Historical research shows that fragmentation generated in this fashion is a prime cause of infantry casualties. For this reason the infantry has frequently used protective flak jackets to provide some protection. According to the battalion commanders at the Battle of Hue the flak jackets significantly reduced the number of casualties produced by B40 rockets that would ricochet from tank hulls and buildings when fired at close ranges.

One of the main employment concepts for using smoke dispensers would be as an ambush response system. In the open it has been traditional to advance or retreat at high speed when ambushed. This may not be possible when tanks are used in built-up areas. Frequently barricades will be erected to prevent the tank from advancing through the ambush. A heavy cover of smoke would be able to protect the infantry and the tank. It should be mentioned that dismounted infantry are still used to accompany tanks in built-up areas.* Ketron has looked into the way many ambushes occur involving tanks in cities. Frequently concealed enemy infantry with small arms will lie in wait for the first AT round to strike the tank. When this occurs it is usual for the enemy infantry to pop up and unload their magazines at the advancing infantry

* Ft. Benning, Ga., Combat in Cities Study, 1972.

of the infantry-tank team. Smoke would allow those infantry being ambushed to degrade enemy fire to a large degree.

An alternative to such a system that was considered was the use of a fire suppression system on the tank. Claymore mines and rapid fire weapons are examples of such systems. Construction of Lanchester models for this type of situation gave us some preliminary results to suggest that a tank mounted smoke dispensing system is superior. Basically, smoke gives a long-term effect that is absent from a fire suppression system.

Liquid smoke chemical could be carried in rolling liquid transporters towed behind one or more tanks. In case of problems, the trailer could be detached and left behind.

(ii) Protective Canopies - The use of protective canopies for the crew tank hatches would allow for substantial increase in visibility. One of the greatest problems in using tanks in urban areas is that it is so easy for the enemy to force tankers to button up. Even hand guns and rocks can force the tank to close up and severely restrict detection of enemy threats. Historical research indicates that a closed tank usually has very poor fire control. The reasons for this are quite obvious; due to lack of observation, crew members are simply unable to readily anticipate or respond to serious threats. In the fighting in Budapest in 1956, Soviet tanks were forced to button up because of random sniper fire. Until this time little fire had come from the tanks. After buttoning up, the tankers resorted to a kind of urban reconnaissance by fire. They fired wildly into buildings on streets causing substantial damage. A protective canopy that would neutralize small arms fire would enable tanks to exploit their mobility capabilities to a much greater degree. A particularly desirable canopy would be a bullet proof

plexiglas type that would provide protection while permitting maximum visibility. This research is very important from the viewpoint of urban warfare and should concentrate on the development of protective canopies for tanks for city use. The canopies should be easy to install on the vehicles and be relatively inexpensive.

(5) Use of Armor in Cities - Findings and Recommendations

(i) Despite our doctrine to the contrary, the tank is a key weapon system in urban combat operations. Survivability can be increased by enabling full 360° direct visibility by a tank crew member during the "ride into town". A transparent protective canopy is one obvious possibility.

(i) Exploratory Development of a transparent canopy resistant to small arms fire and HE fragments is recommended.

(ii) Smoke devices that can produce the persistency and density of smoke required to provide concealment for armor are highly desirable as a means of neutralizing the advantages in visibility accruing to weapon emplacements exploiting indigenous structures for concealment.

(ii) Further study should be undertaken to determine optimum densities and persistence characteristics for smoke dispensing systems. Exploratory Development of improved vehicular mounted systems to provide the quantities of smoke required should be initiated.

(iii) U.S. doctrine for the employment of armor in cities is inadequate in concept and statement.

(iii) U.S. doctrine prescribing procedures for using tanks in cities have been reviewed and found to require extensive revision and expansion to exploit their full potential.

IV.3.4 Precision Guided Munitions

(1) General - During the past several years a great deal of effort has been directed toward the development of precision guidance systems for munitions delivery. Precision guidance has emerged as a promising technology -- the application of which has been verified by the performance of laser and TV guided bombs in Southeast Asia. The extreme accuracy achieved by these techniques produces significant increases in munitions effectiveness, outweighing the additional expense incurred when a sophisticated electro-optical guidance package is included in the expended munition.

The discrimination capability of precision guided munitions yields benefits directly applicable to the urban environment. The massive destruction which accompanies the engagement of armies in built-up areas may to some degree be lessened. Delivering fewer munitions closer to the target can certainly be instrumental in limiting the collateral damage to physical property and casualties to non-belligerents.

In addition to these advantages, the utilization of such weapons in cities poses a number of problems. The severity of the environment provides visual obstruction at even short ranges. Tests of PGMs in a field type situation will not give information for their effective use in the city. Countermeasures and mutual interference problems must be considered in the context of the urban situation. The high accuracy loses its significance when a building shadows the trajectory from the target. Short-range performance (hundreds of feet) required in street fighting may not be adequate for systems designed for long-range application (thousands of feet).

Therefore, the need is evident to determine the operational limitations imposed by the urban terrain and to evaluate the performance of present or proposed PGM systems as they would be affected by urban conditions. Little has been done to determine their urban applicability

with respect to designator-to-target-to-sensor-to-launcher geometries and guidance link energetics. Weapons are under development for acquisition in the late 1970s. It is necessary to determine how these systems will perform and to set requirements for desired performance and concepts of employment which are commensurate with the situations encountered in built-up regions. Current laser weapon research in the PGM area is concerned with development of search and track sets for target acquisition, rangefinders for accurate range measurement, and designators for illuminating the target. Some of these systems are used in a multipurpose role, for example, designator/rangefinder. There are some thirty such systems currently in use or development. Each of the armed services is undertaking developments of munitions which have laser homing capability. These munitions are specified in terms of weight, accuracy, seeker field of view, velocity, and range. Hence a great deal of quantified data are available to estimate performance of these systems.

Additional research has been conducted to measure reflectivity of laser beams from different surfaces including structural materials. The results of this research relate reflected energy, source energy, angle of incidence, viewing angle, and other physical variables as well as surface type.

(2) Analysis of Current Capabilities -

(i) Operational Description - The application of lasers to combat situations has taken the form of laser guided bombs used in Southeast Asia for missions involving high accuracy. The technique involved consists of illuminating the target with a designator which may be located on board the aircraft which drops the bomb or on board a companion aircraft. (The laser designation could also be undertaken by an infantryman in a ground position near the target. This technique is

currently being investigated in conjunction with other types of delivery systems such as missiles or artillery.) The bomb which is dropped contains a seeker which homes in on the energy reflected from the target. A computer sends guidance instructions to control surfaces or steering vanes on the tail of the bomb. This homing procedure is initiated at some point after the bomb is dropped. Prior to homing, the bomb follows a conventional ballistic trajectory. Once initiated the homing process takes place until the time of impact. Hence it is necessary that the designator continuously illuminate the target throughout the terminal phase.

Another technique to achieve accuracy employs television camera guidance. In this method the bomb has a TV camera in its noise and a crew member aboard the aircraft locks the camera on target. The bomb is then released and is automatically guided to the target without operator intervention. This is a distinct advantage over laser guidance. Current TV systems require daylight and a high contrast target. Urban targets are often high contrast.

(ii) Operational Effectiveness - The effectiveness of laser bombs has been demonstrated in a number of situations in Vietnam. Of particular interest are the destruction of Long Bien bridge crossing the Red River in Hanoi, as well as the Thankhoa bridge. According to <u>Aviation Week</u>, 3000 lb laser bombs dropped by Air Force F4 Phantom jets have been employed in such attacks. These bombs are World War II bombs modified by special kits containing the control and sensing devices. Another interesting example is found in the Kham Thien area. Attacks were directed at the main railway yards near the Kham Thien commercial and residential district by F4s with laser guided bombs, destroying or damaging the terminal, administration building, loading platforms, and five tracks. Additional attacks were made on the Gia Lam

airfield and to the city's thermal power plant. Detailed bomb damage photographs taken by reconnaissance drones appeared to verify that only light damage was done to civilian structures near the plant. On the other hand, premature bomb drops of conventional bombs were blamed for severe damage to several buildings near Bach Mai civilian hospital.

As a rule of thumb, for the delivery of guided bombs, "Given an average day, you can expect more than 50 percent of the bomb impacts to be direct hits."*

(3) Delivery Error - In the analysis of ordnance delivery, one can attribute the inaccuracies experienced to target location errors, fire control errors, and ballistic errors. The PGM system provides a means for correcting these errors and thereby reduces the number of rounds required to destroy the target.

Another advantage of PGMs is the ability to achieve first round hits which permit an element of surprise. Conventional artillery requires a forward observer to transmit information to the fire control center which adjusts successive rounds to bracket the target. The enemy is thereby given time to decrease its vulnerability as the necessary calculations and adjustments are made to bring in fire for effect volleys. But when laser guidance is employed a relatively inaccurate first round can be corrected in flight to achieve relatively high accuracy.

A recent study**has compared the performance of laser guided bombs and artillery against conventional ordnance to assess the

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* "What Every Ground Commander Should Know About Guided Bombs", Army, June 1973.

** An Effectiveness Analysis of Fire Support Systems for SIAF Ground Combat Units, C. R. Peer, TRW, May 15, 1972.

effectiveness of these munitions. This study points out that extensive firing tests at Fort Hood determined that 53 percent of total system delivery error are due to target location errors: error in estimating range and position of target relative to forward observer and error in position estimate of forward observer in grid relative to the fire direction center. These tests further showed that target location errors under good conditions are on the order of 225 meters, while laser range-finder triangulation reduced the expected error to 24 meters. A 50-meter target would require 1/3 the number of volleys to achieve 30 percent damage.

Analytical investigations* have indicated that the original error can be reduced to about 25 percent of its initial value (that is, 200-meter miss distance would be reduced to 50 meters). A number of effectiveness curves have been developed showing increase in effectiveness of about 300 percent by employing PGMs (that is, four times as many volleys were required to achieve a given damage level using conventional munitions rather than PGMs for 155 mm HOW operating at ranges out to the maximum of 14 kilometers).

(4) Urban Environmental Factors - The city geometry introduces the element of trajectory shadowing, or intercept by structures of munitions aimed at other structures. Such intercept both decreases the effectiveness of the munitions and produces a great deal of undesirable damage.

The built-up environment also produces reduced visibility and mobility which can both be factors in the employment of PGMs. Figure 31 illustrates some of the aspects of the problem.

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* An Effectiveness Analysis of Fire Support Systems for SIAF Ground Combat Units, C. R. Peer, TRW, May 15, 1972.

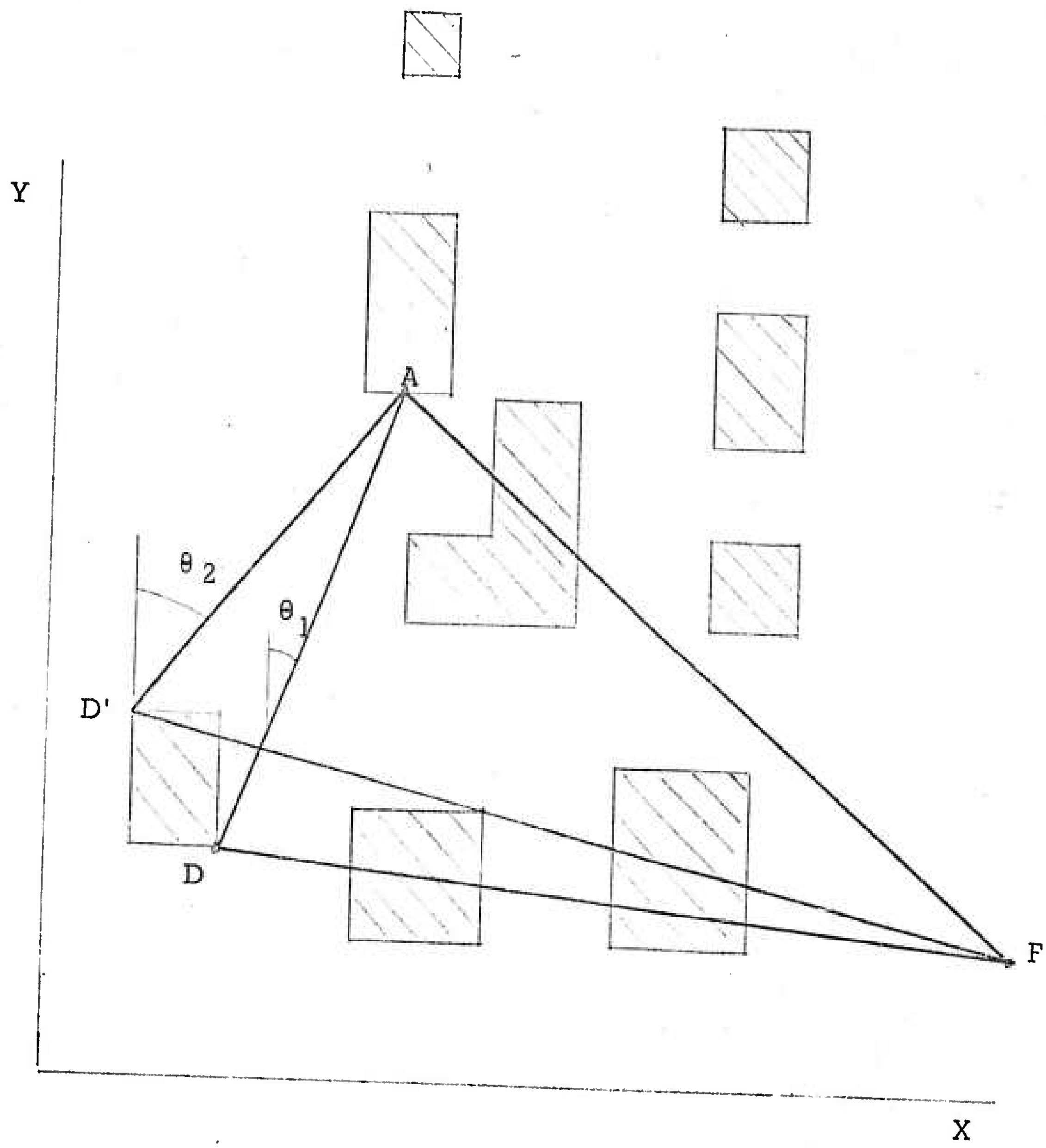

Figure 31: Urban Intervisibility Geometry

The figure represents an aerial view of a built-up area with a firing position at F, forward observer at D, and enemy strongpoint at A. If the element of surprise is to be achieved, it is required to fire from F to A without the long bracketing time required using conventional techniques. Thus the observer at D uses a laser designator to illuminate the target A. To do so effectively, he must first report his own position, X_D, Y_D in the common grid and report the position of the target relative to his position. If he is equipped with a designator/rangefinder, he can accurately measure the range DA, but his error in measuring bearing angle θ could render useless his accurate range measurement. If θ is known accurately, along with X_D, Y_D, then the firing range FA can be accurately determined. However, if he is unfamiliar with the city, he may not be reporting his own position accurately.

These inaccuracies would mean that the initial round could be well off target. If the round is a PGM round, then it may be capable of correcting the target location error, depending on the size of the error and the capability of the correction system.

If another designator is located at D', then a second triangulation can be performed so that an improved estimate of range FA can be obtained. The use of additional measurements (designators) or cooperation between D and D' could improve the accuracy. Once the PGM is launched the intercept of its trajectory by an intervening structure is possible. Unless the fire control system has information on intervening structures, or a structural data base, it is difficult to predict such a shadowing problem. Figure 32 illustrates the problem reduced to two dimensions. Trajectories 1 and 2 will not be effective despite the laser guidance capability, while trajectory 3 has a chance of hitting the target.

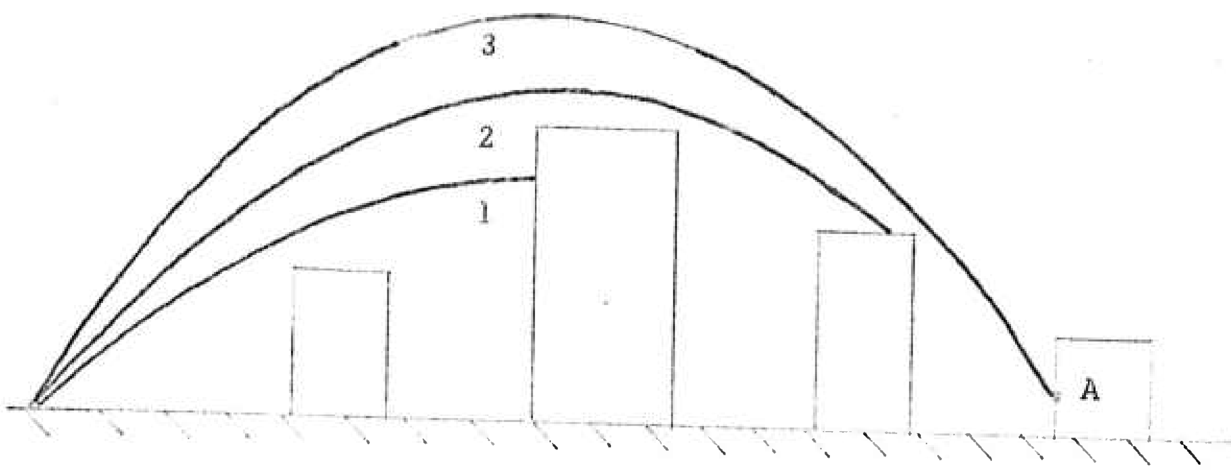

Figure 32: Urban Trajectory Geometry

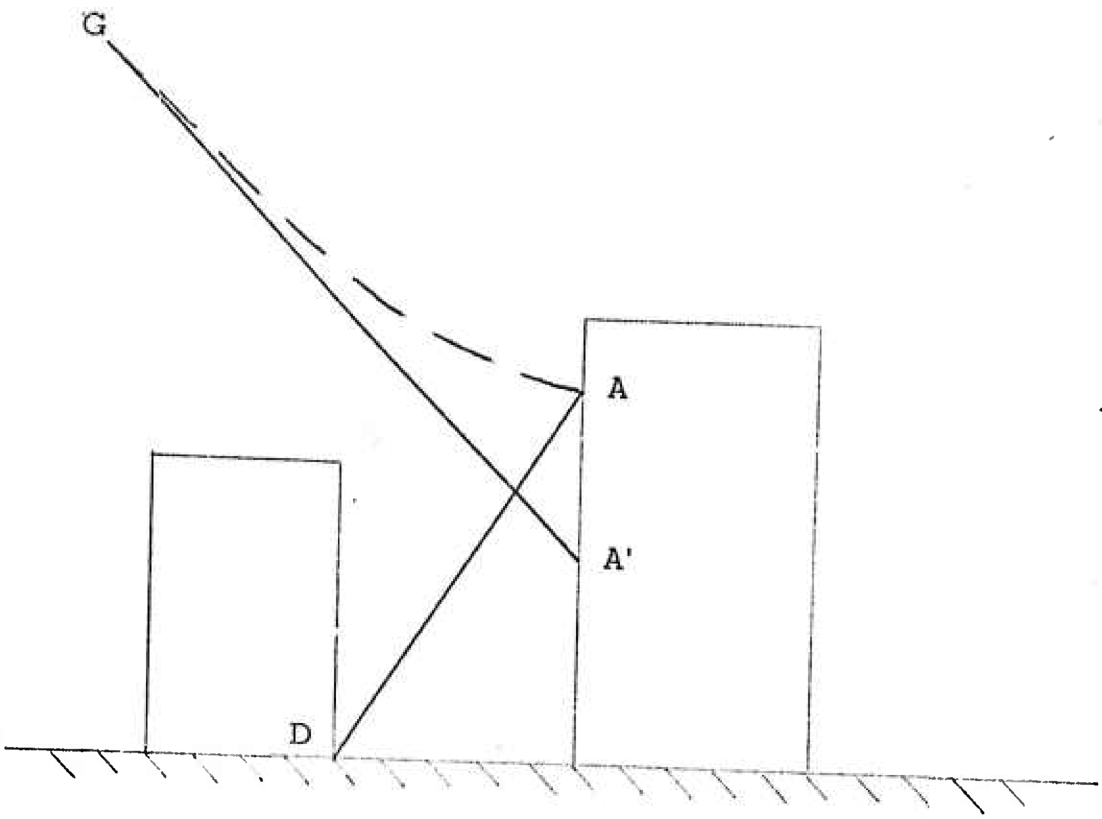

Figure 33: Terminal Guidance Geometry

If the trajectory is such that it is not intercepted by an intervening building, then the terminal phase can be initiated. At this point, the target is illuminated and homing can begin. Figure 33 illustrates the situation. Terminal guidance is initiated at G, the designator illuminates point A, while the ballistic trajectory is aimed at A'. The dashed line represents the corrected trajectory.

In order for the correction to be made it is necessary that:

- Sufficient energy be reflected from A toward the seeker
- The designator spot lies within the field of view of the seeker
- Sufficient maneuver capability exist in the missile to make the correction

(5) Reflected Energy Measurement - One of the aspects which is of importance in the design of laser guidance systems is the reflection of energy from the target. As the laser beam strikes the surface of the target, energy is reflected which is received by the seeker. The homing commands which are initiated by this process require that sufficient energy be received.

The amount of energy which is received by the seeker depends upon, in general,

- The laser output energy
- Atmospheric conditions
- Distances between designator, target, and seeker
- Angle of incidence of beam
- Aspect angle of seeker
- Surface conditions of target

A number of studies* have been conducted to develop data on reflectivity of different surfaces. This data is useful in analyzing the performance of candidate weapons systems against targets having these reflectivity properties. The results show that wet surfaces reflect considerably less energy than do dry surfaces. This variation can range from a few percent to significant amounts.

This study compares reflectivity relative to the performance of an ideal diffuse reflector. A perfect reflector is defined by

$$U_k = U_n \cos \theta \qquad (1)$$

where U_k = reflected energy density per joule transmitted by the laser at a given distance from the target.

U_n = reflected energy density per joule at the same distance and normal to the target.

θ = angle between normal to target and reflected radiation.

The results show that equation (1) represents a reasonable approximation to the reflectivity with the following coefficients:

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* • Laser Reflectivity Measurements at 1.06 Microns from an M41 Tank, U.S. Army Missile Comm., Redstone Arsenal, May 66, AD #374707.
- Laser Reflectivity Measurements at 1.06 Microns, Roy and Emmonds, U.S. Army Missile Comm., Oct. 65, AD #368115.
- Laser Air Defense Study, Aero Sys. Div., Jam. 66, AD #371191.
- Lash Homing Projectile Weapons System, Honeywell, Inc., Oct. 65, AD #370953.
- Some Guidelines to the Prediction of Reflected Energy from Laser ILLU etc., Ballistic Research Labs., Jan., 70, AD #864437.

Material	U_n
Perfect reflector	1.
Dry, old grass	.8
White painted tile	.5
Concrete	.16
Red dirt	.06

Looking at O.D. painted metal, the above cosine relationship is not valid. Instead, the reflectivity drops off more quickly with θ. For $\theta = 30^\circ$ U_k is about 1/12 of its value at $\theta = 0^\circ$ for a dry clean surface, exhibiting a strong peak, and varying between 2.5 to 4%. Figure 34 illustrates the geometry. The results of the analysis show that the relative reflectivity is approximately in the following ratios:

White Painted Tile Blocks (clean and dry)	9
Concrete (clean and dry)	3
Red Dirt or Mud	1

for values of θ between 5° and 80°.

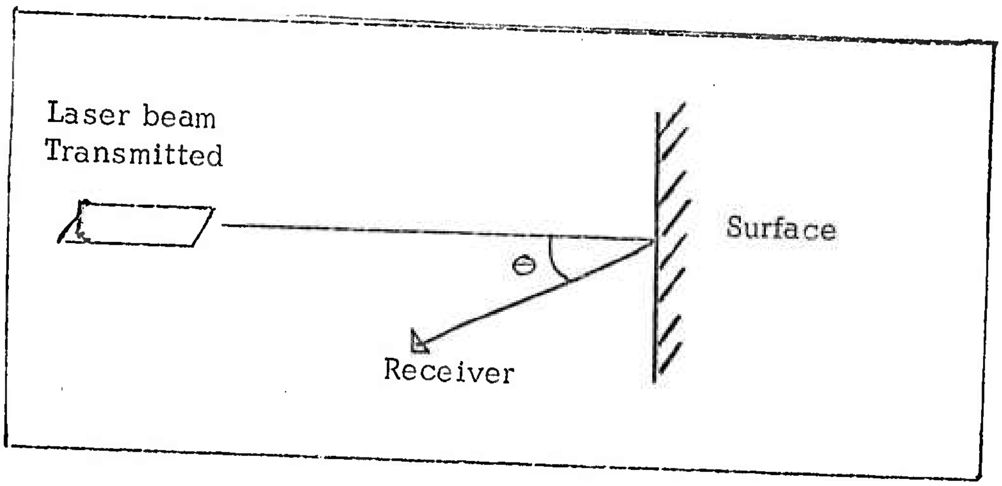

Figure 34: Laser Designator Geometry

The data obtained in these studies are designed for use in evaluating the performance of laser homing devices. By including the effect of atmospheric losses in energy density during transmission of the beam to the target and reception from the target by the seeker, one can determine the requirements for employing such devices in urban engagements.

(6) Limiting Collateral Damage - The PGM, because of its accuracy, provides a means whereby damage in cities may be greatly limited. This can be due to the increased delivery precision, but equally as well due to the reduced time to achieve the objective — the long drawn out battle is much more likely to produce great amounts of damage. A quantitative example is studies in Section IV.3.4 (8).

(7) Cost Trade-Off - The comparison of effectiveness of PGMs vs. conventional weapons is, of course, a complex problem. If one takes into account R&D and operational logistics costs, it can become even more so. The purpose of this discussion is to illustrate a rather simple trade-off which can be made.

Let us assume that the accuracy of the weapon is related linearly to the range, such that $\sigma = b_i R + \sigma_o$

where

σ = standard deviation

σ_o = constant term

R = range

b_i = constant for weapon type i

Based on data in reference [*] we can evaluate the conventional and laser weapon constants, b_C and b_L. It should be noted that the σ

* An Effectiveness Analysis of Fire Support Systems for SIAF Ground Combat Units, C.R. Peer, TRW, May 15, 1972.

for a sophisticated PGM could be relatively range independent such that the value of σ is determined primarily by the constant term σ_o. However, for a nonsophisticated one-shot correction system the σ would increase with range. For the purpose of this discussion the simplifying assumption is made that σ varies linearly with range and the constant term (σ_o) is small such that $\sigma = b_i R$.

One might model the cost trade-offs with the following set of equations:

$$C_L = C_{L0} + U_L N_L \qquad C_C = C_{C0} + U_C N_C$$

$$N_L = 1 + A_L R_L^{\alpha} \qquad N_C = 1 + A_C R^{\beta}$$

where L denotes laser and C denotes conventional weapon and:

N_i = Number of payloads to obtain the objective

R_i = Target range

U_i = Unit payload cost

A_i, α, β = Weapon effectiveness measures

and we can assume:

$$\beta > \alpha$$

$$U_L > U_C$$

For very short ranges one would expect the conventional weapon to be effective, but the laser weapon would begin to outperform the conventional weapon at some range R*. This range is obtained by equating C_L and C_C,

$$C_{L0} + U_L \,(1 + A_L R_L^{\alpha}) \quad = \quad C_{C0} + U_C \,(1 + A_C R^{\beta})$$

The best estimates for U_L and U_C would be assumed while A_i, α and β could be obtained from Monte Carlo running of MASK. For example, if we assume $\alpha = 1$ and $\beta = 2$, we would have:

$$U_C A_C R^2 - U_L A_L R + U_C - U_L + C_{C0} - C_{L0} = 0$$

and solving for R,

$$R^* = (U_L A_L + \sqrt{U_L^2 A_L^2 + 4\, U_C A_C\, [U_C - U_L - C_{C0} + C_{L0}}])/2\, U_L A_L$$

or graphically

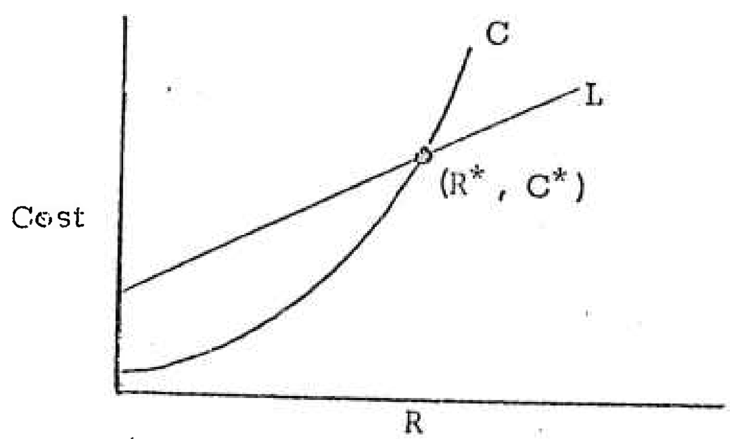

Figure 35: Determination of Economic Crossover Range.

The coefficients A_L, A_C would depend on attack bearing angle θ,

$$A_L = f_L\,(\theta), \quad A_C = f_C\,(\theta)$$

which is another variable to be considered.

One might also want to determine the unit cost U_L for which smart weapons are worthwhile. Solving the above equation for U_L

$$U_L = (U_C A_C R^2 + U_C + C_{C0} - C_{L0})/(1 + A_L R_L)^{\beta}$$

One can now take a look at the feasibility of obtaining a smart weapon for unit costs in this region of values.

By choosing a given operating range, R, the values for σ_C and σ_L are obtained from $\sigma_i = b_i R$. The MASK model is used to obtain P_{HC} and P_{HL}, i.e., the single shot hit probabilities for each weapon type. If we assume each shot is independent, and our objective is to achieve a probability of P_{HN} of making at least one hit with N rounds, then

$$N_i = \log(1 - P_{HN}) \,/\, \log(1 - P_{Hi})$$

is the number of rounds of each weapon type required. By varying R we can thereby obtain $N_i(R)$ for each weapon type.

If we assume the ratio of weapon unit costs is defined by

$$K_C = U_L \,/\, U_C$$

then we can define a simplified crossover range as that range R where both systems yield the same cost to achieve a hit with probability P_{HN}, i.e., as the solution to

$$C_L = C_C = U_L N_L(R) = U_C N_C(R)$$

or

$$\frac{N_C(R)}{N_L(R)} = \frac{U_L}{U_C} = k_C .$$

(8) Effectiveness Evaluation of PGMs -

(i) Collateral Damage - The MASK model was used to study the effect of increased weapon accuracy on reducing damage and achieving desired hits more readily. A historic situation was used, namely the Warsaw uprising in 1944. Figure 36 illustrates the section of the city involved. The Poles captured the Kammler Factory while the German strongpoint was located at the tobacco factory.

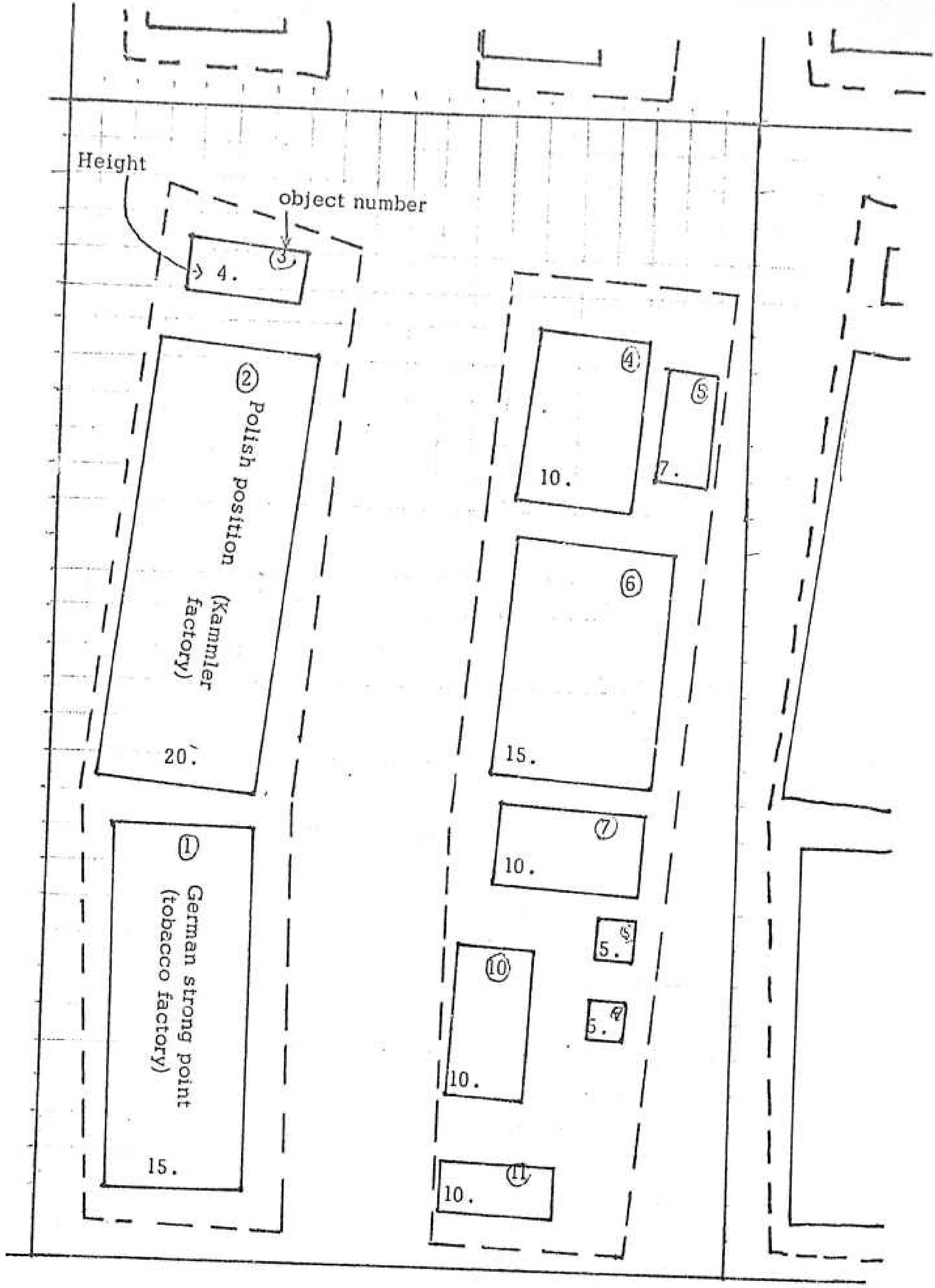

Figure 36: Section of City Involved in Warsaw Uprising

By employing MASK we can study the effect of a number of key factors, for example,

- High angle vs low angle fire
- Firing direction
- Weapon accuracy
- Aimpoint
- Street width
- Building size

The weapon delivery error is defined by a two dimensional normal distribution defined by σ_E and σ_A. For this study, a single parameter $\sigma_E = \sigma_A = \sigma$ was chosen. Let P_H be the probability of hitting the desired structure (tobacco factory) and P_D be the probability of inflicting significant collateral damage. The aim point was the center of the roof of the target structure. Figures 37 and 38 show the variation of P_H and P_D with σ for low angle ($\gamma = 45^\circ$) and high angle ($\gamma = 75^\circ$) fire. The high angle fire is slightly better in optimizing P_H and reducing P_D. These figures are for fire delivered from due east, $\theta = 0^\circ$.

Figure 39 shows an average value of P_H for different munition fall angles γ and firing directions, θ measured counter-clockwise from east. Figure 40 shows the spread in P_D for $\gamma = 45^\circ$ and 75° and $\theta = 0^\circ$ and 75°. The figures show that reducing the delivery accuracy to $\sigma = 50$ ft has high payoff in reducing collateral damage and achieving a high value of P_H. But a more useful measure of collateral damage is the expected number of collateral hits, N_D, incurred in achieving at least one hit on the target at a prescribed probability level P_{HN}. Assuming independence between rounds, the number of

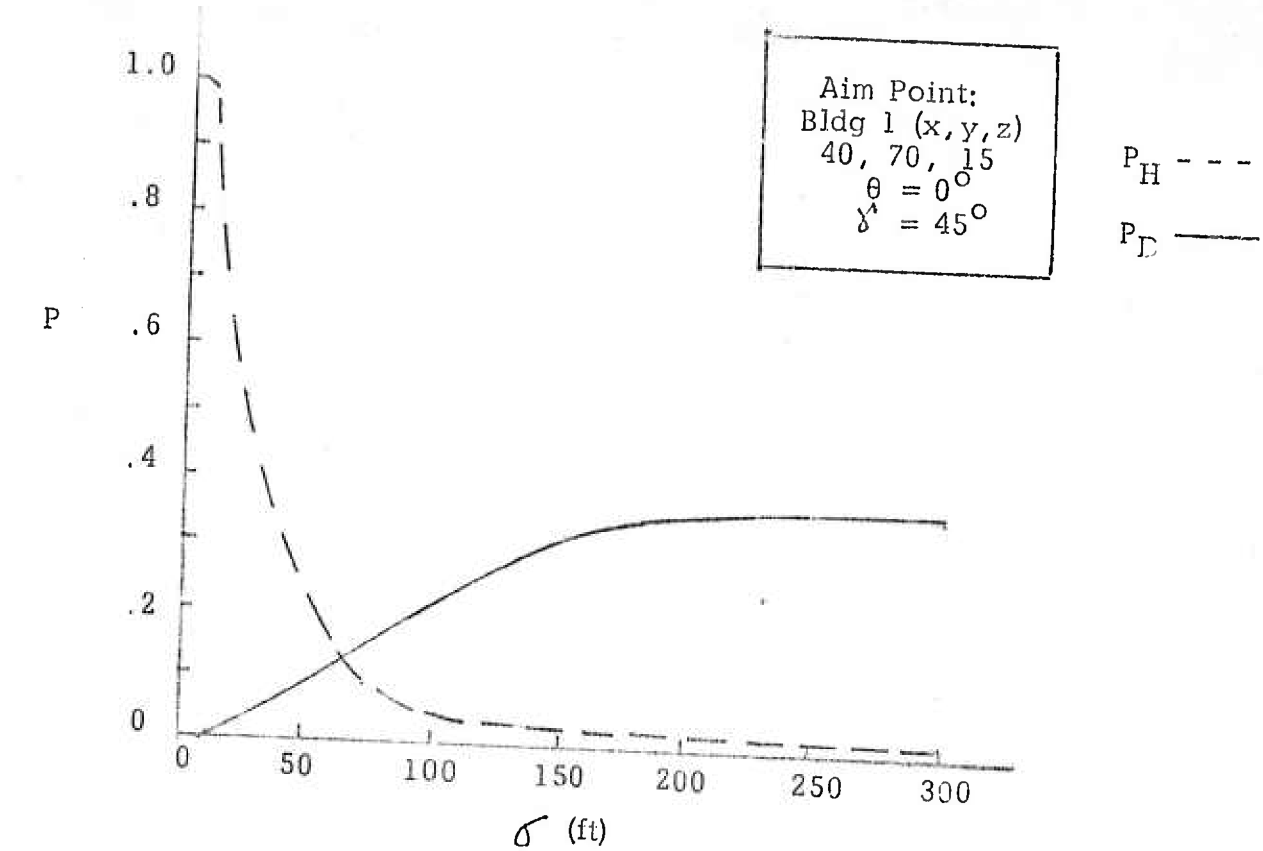

Figure 37: Variation of P_H and P_D with Weapon Accuracy Low Angle Fire

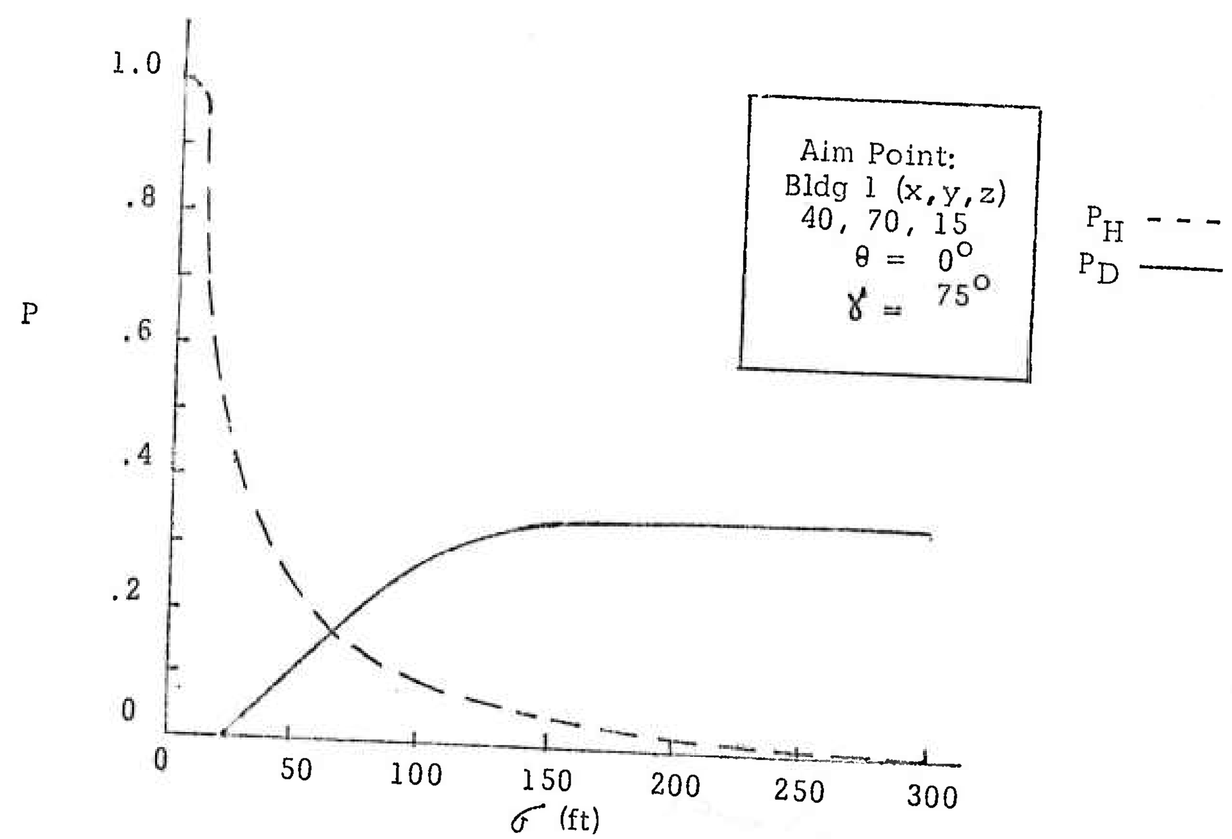

Figure 38: Variation of P_H and P_D with Weapon Accuracy High Angle Fire

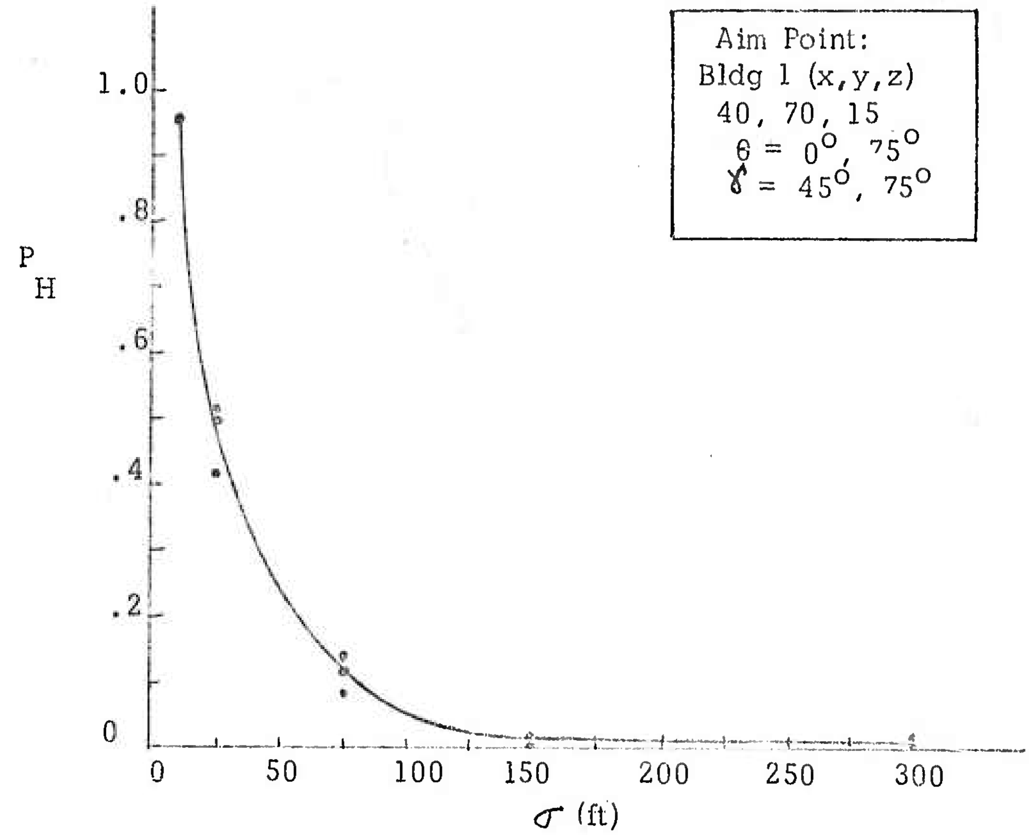

Figure 39: Average Value of P_H vs. Weapon Accuracy

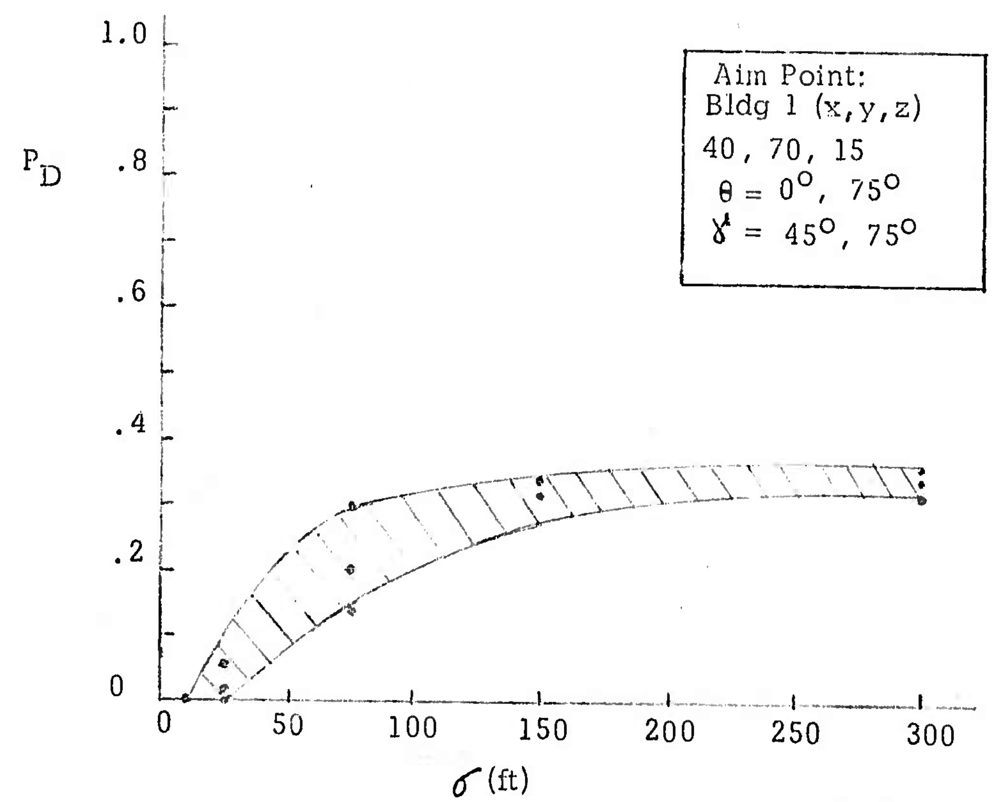

Figure 40: Spread of P_D vs. Weapon Accuracy

rounds, N, required to achieve at least one hit on the target at probability level P_{HN} is

$$N = \log (1 - P_{HN}) / \log (1 - P_H)$$

where P_H is the single shot hit probability. But each of these N rounds has a probability P_D of hitting a nontarget building or other structure distinct from streets or open areas. So

$$N_D = NP_D = P_D \log (1 - P_{HN}) / \log (1 - P_H) .$$

Choosing, for convenience, $P_{HN} = .9$, and letting P_H, P_D and N_D be functions of the delivery accuracy σ, we have

$$N_D(\sigma) = - P_D(\sigma) / \mathrm{Log}_{10} (1 - P_H(\sigma)),$$

which is computed from the data of Figures 39 and 40, and plotted in Figure 41. This shows that fires with delivery accuracies (σ) of 25 feet or less cause insignificant collateral damage, but larger σ's cause rapidly accelerating collateral damage since so many rounds are required to hit the target, and a larger percentage of the misses hit collateral structures.

(ii) Cost and Time Effects - In order to compare conventional vs. precision guided munitions on a cost basis, a simplified analysis was performed. Here, the concern is with the number of shots required to obtain a desired objective with and without the advantages of laser guidance. Since PGMs cost more per round but are more accurate, the critical question is at what range it becomes more effective to use them. Furthermore, it is desirable to achieve an objective quickly, and if this can be done in less time, (that is, fewer rounds) other advantages can accrue to the fighting force.

To perform this analysis, the following assumptions were made:

- σ varies linearly with firing range, $\sigma_i = b_i R$;
- The objective is to achieve $P_{HN} = .95$ with N rounds

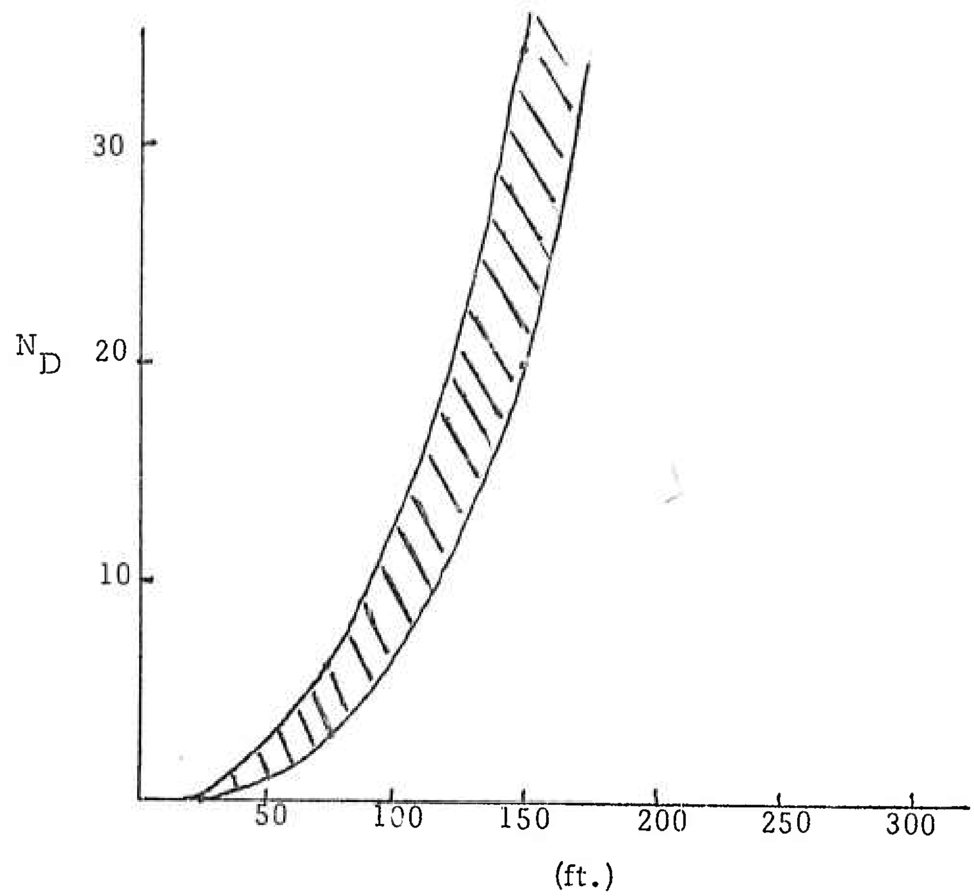

Figure 41: Index of Collateral Damage vs. Weapon Accuracy

- Each round is independently fired; hence

$$N = \log(1 - P_{HN}) / \log(1 - P_H)$$

and P_H is the single shot hit probability.

The values of b are taken to be, for conventional and laser guided weapons,

$$b_C = 300 \text{ ft}/14 \text{ km}.$$
$$b_L = 75 \text{ ft}/14 \text{ km}.$$

Now, the following procedure was used:

1. Choose firing range, R
2. Evaluate σ_C, σ_L
3. Use Figure 39 to obtain P_H for each weapon;
4. Evaluate number of rounds required for each weapon;
5. Plot N vs. R for each weapon.

Figure 42, shows the variation of number of rounds to obtain $P_H = .95$ vs. firing range.

A cost comparison is made by assuming that the unit costs are given by:

$$U_C = 1$$
$$U_L = 5$$

Figure 43 shows the cost curves $C_C = U_C N_C$, $C_L = U_L N_L$ as they vary with firing range. The crossover point occurs when $C_C = C_L$ at R = 1.25 km.

The crossover point will, of course, depend on the ratio U_L/U_C. From Figure 43 it is evident that if $U_L < 5U_C$, the crossover will occur at a lower range. To show this effect, U_L/U_C was varied between 1 and 20. Figure 44 shows the range at which $C_C = C_L$ for different ratios U_L/U_C.

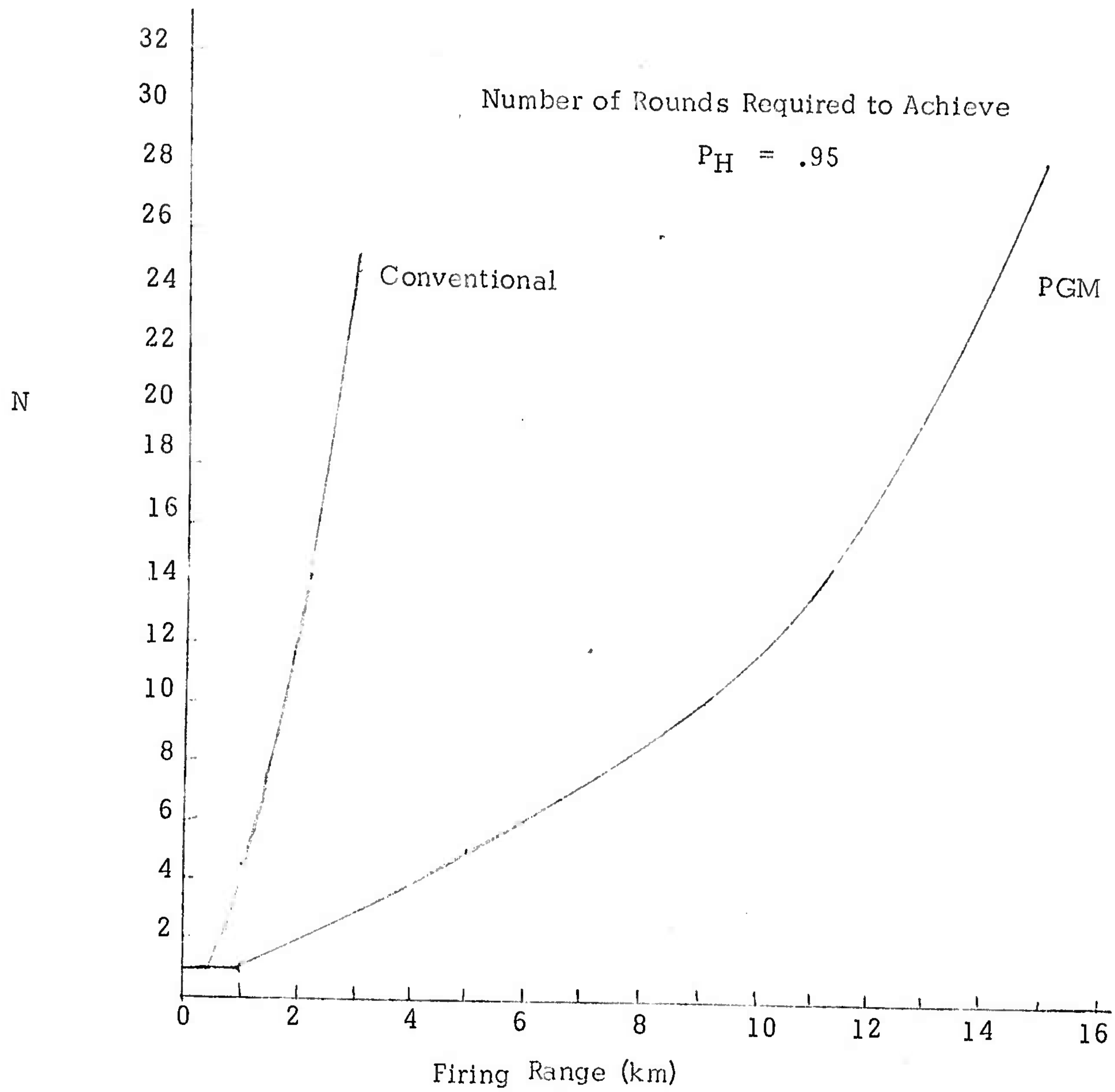

Figure 42: Data Used to Obtain $P_H(\sigma)$.

$$N = \frac{\log(1-P_{HN})}{\log(1-P_H)}$$

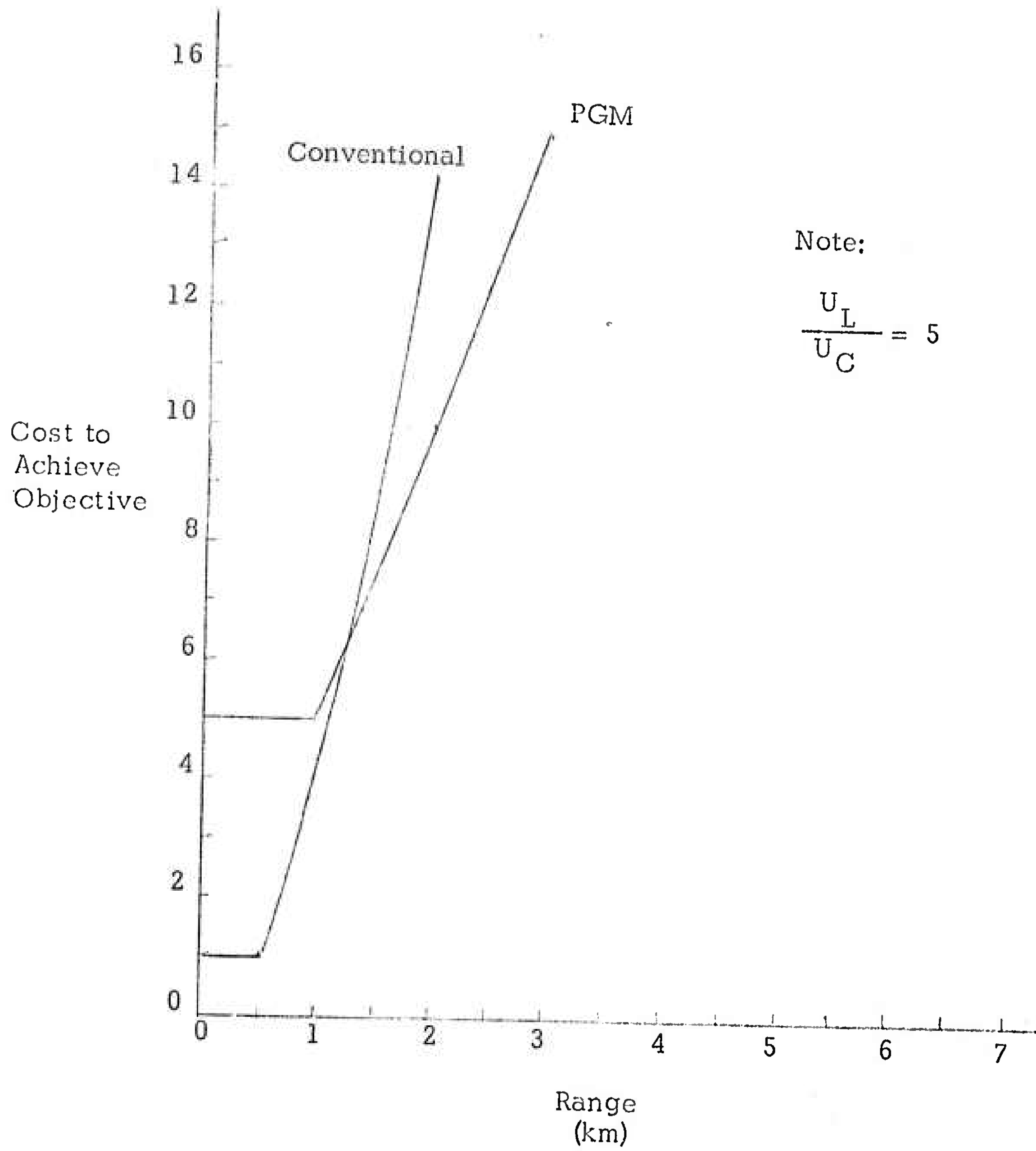

Figure 43: Costs to Achieve Objective

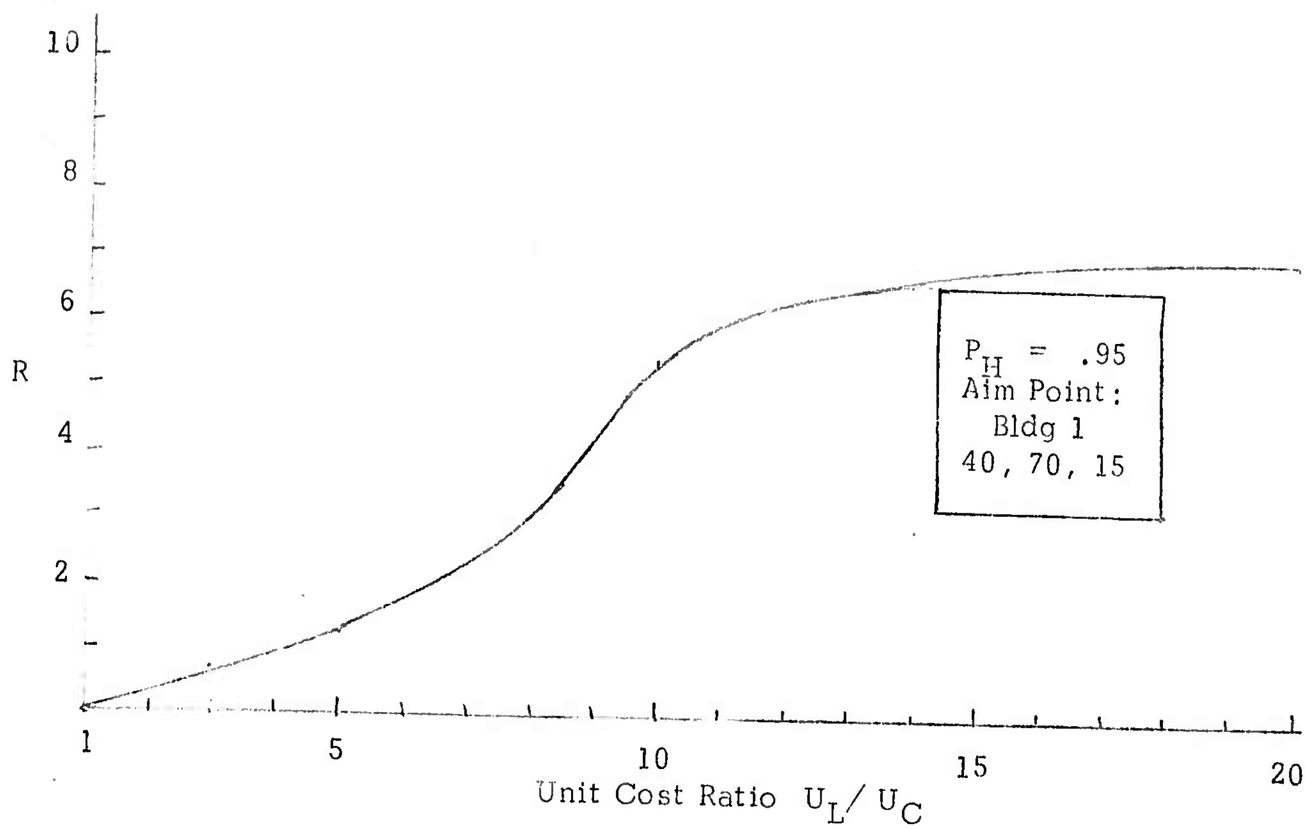

Figure 44: Firing Range at which PGM and Conventional Munitions have Equal Cost to Achieve Similar Objective

This analysis is not intended to describe the complete problem, but it does provide a basis for comparison of PGM and conventional systems. An accurate assessment of relative costs, logistics and supply effects, and other factors such as building spacing and height, weapon yield, weight, and damage capability should be made before any general conclusions are reached.

(iii) Visibility Effects - One of the major areas where difficulties can be encountered when employing PGMs in the city will be in the visibility area. A foot soldier carrying a hand-held designator must get to a point where the target can be visually sighted. He must then designate the target and call in fire. The designated spot must be visible also to the seeker on the PGM. These visibility problems are analogous to the trajectory masking which has been discussed earlier.

In order to study the problem, a computer model CITY/FIGHT 1* has been developed. CITY/FIGHT 1 has other uses at present, but it is being extended to evaluate the effectiveness of:

- Hand-held vs. airborne laser designator operating in a city
- Geometric effects of aspect angle, energy received by sensor, and surface reflectivity
- Terminal accuracy problems
- Designator aim point and weapon effectiveness

The method of extending the model is to incorporate the work of other researchers. Data and tables can be used which represent the physical parameters of accuracy and reflectivity and which can be used to study visibility problems encountered in the city.

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* A description of CITY/FIGHT 1 is given in Appendix C.

Another effect of visibility is its relation to the maneuvering requirements that are imposed on a PGM. The aim point may be at some distance below the top of the building and of the surrounding buildings. Consequently, if this point is being designated it may not become visible to the seeker or it may become visible too late to perform the corrective maneuver. A number of parameters come into play in the analysis of this problem:

- Seeker viewing cone angle
- Munition velocity
- Laser power, and seeker sensitivity
- Reflectivity of the aimpoint
- Trajectory, designator geometry
- Building spacing and height

Figure 45 illustrates a projectile aimed at building 1 where it will impact at point I. The projectile has a seeker with a viewing cone angle 2α, and is travelling at an angle γ with the horizontal. A laser designator is aimed at point D, below I, and the designated spot comes into view. The projectile must now execute a pull down maneuver in an attempt to hit point D. If h is the distance between I and D, then for small angles the maneuver requirement is approximated by:

$$ng = \frac{2V^2 \sin^2 \alpha}{h \cos \gamma}$$

where n = number of g's required
g = 32.2 fps^2
V = projectile velocity, fps.

Assuming $\alpha = 15^{\circ}$, $\gamma = 45^{\circ}$, $h = 100$ ft.,

$$n = 5.9 \times 10^{-4} V^2$$

If we set $V = 100\ k$

$$n = 5.9\ k^2$$

which means that 5.9 g's are required at 100 fps of velocity ($k = 1$). A high velocity projectile, say $V = 500$ fps, will require $\approx$ 150 g's.

Although there is a great deal more to the problem, it is important to consider effects such as these in analyzing the requirements for PGM performance in cities. It may be necessary to use low speed projectiles, perhaps even RPVs to perform the tight maneuvers which are likely to be required in urban terrain.

An alternative form of designation which may allow for impacting lower on the structure without the prohibitive high g pull down maneuver is shown in Figure 46. Here the designator is aimed near the top of the building at D_o to allow for early detection by the seeker. Once the homing starts, the designated spot is moved at a predetermined rate until it becomes coincident with the desired impact point, P. The velocity of movement must be such that the point is not lost by the seeker, (that is, it cannot cross the conic field of view). In this way, it may be possible to reduce the maneuver requirement. The designated spot will move significantly slower than the projectile velocity, and it may be possible to accomplish the homing with a pursuit guidance system, rather than with more expensive proportional navigation.

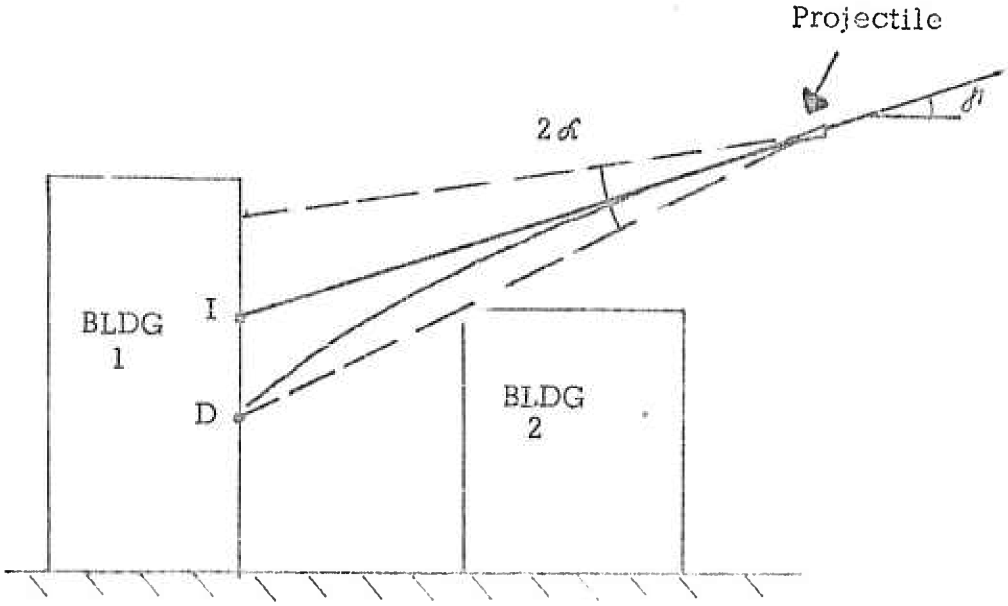


Figure 45: Illustration of "Pull Down" Maneuver

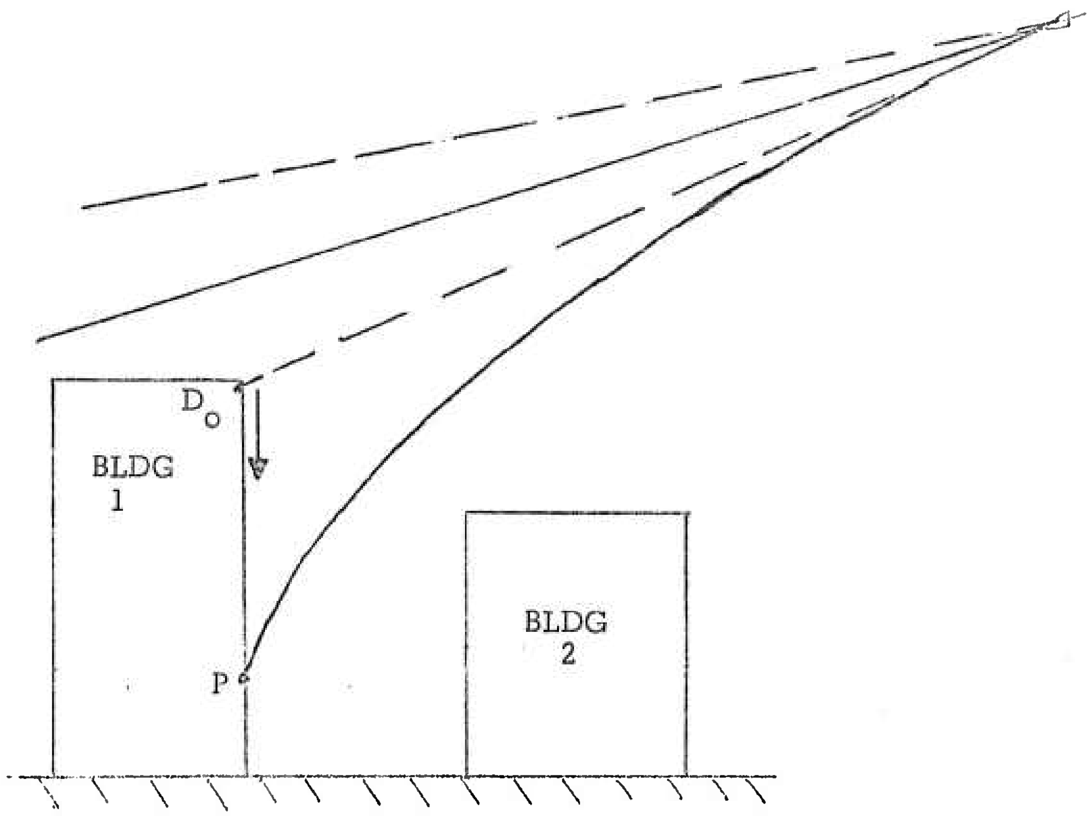
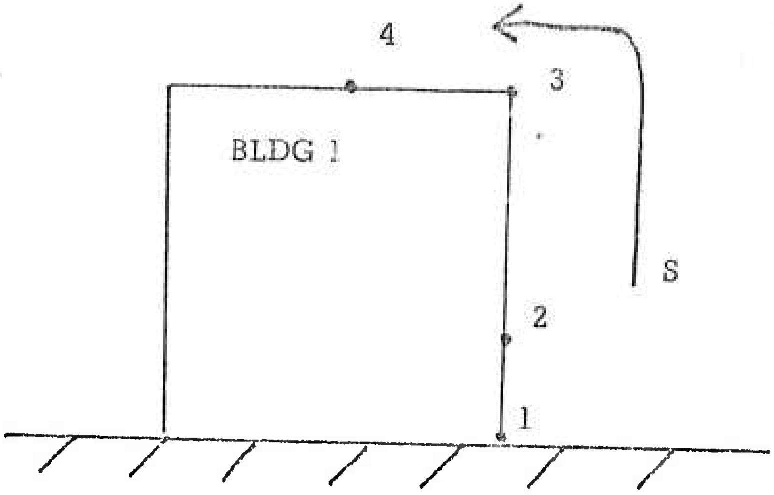


Figure 46: Effect of Moving Designator Beam

(iv) Aim Point and Firing Angle Effects - Figure 47 shows the variation of P_H with aim point. The distance S is measured along the building and the point numbering is according to the diagram below. Aim point 1 is at the building base, while 4 is at the center



of the roof. Aimpoint 2, 5 ft. from the ground provides the best value of P_H for the value of $\sigma = 25'$. It would be possible to use a hand held designator for aimpoints 1,2,3 while 3 and 4 will be more likely with an airborne designator.

Figure 48 shows the variation of P_H with firing angle. The maximum value obtained from the four runs is $P_H = .64$ for $\gamma = 68.7^{\circ}$. This value was chosen because it is the angle at which the building cross section is maximum.

For the tobacco factory, the cross section A, when firing from east, is obtained by projecting the area of the roof and east facing wall on the fall angle vector, i.e.,

$$A = (A_W, A_R) \cdot (\cos \gamma, \sin \gamma)$$

$$A = A_W \cos \gamma + A_R \sin \gamma$$

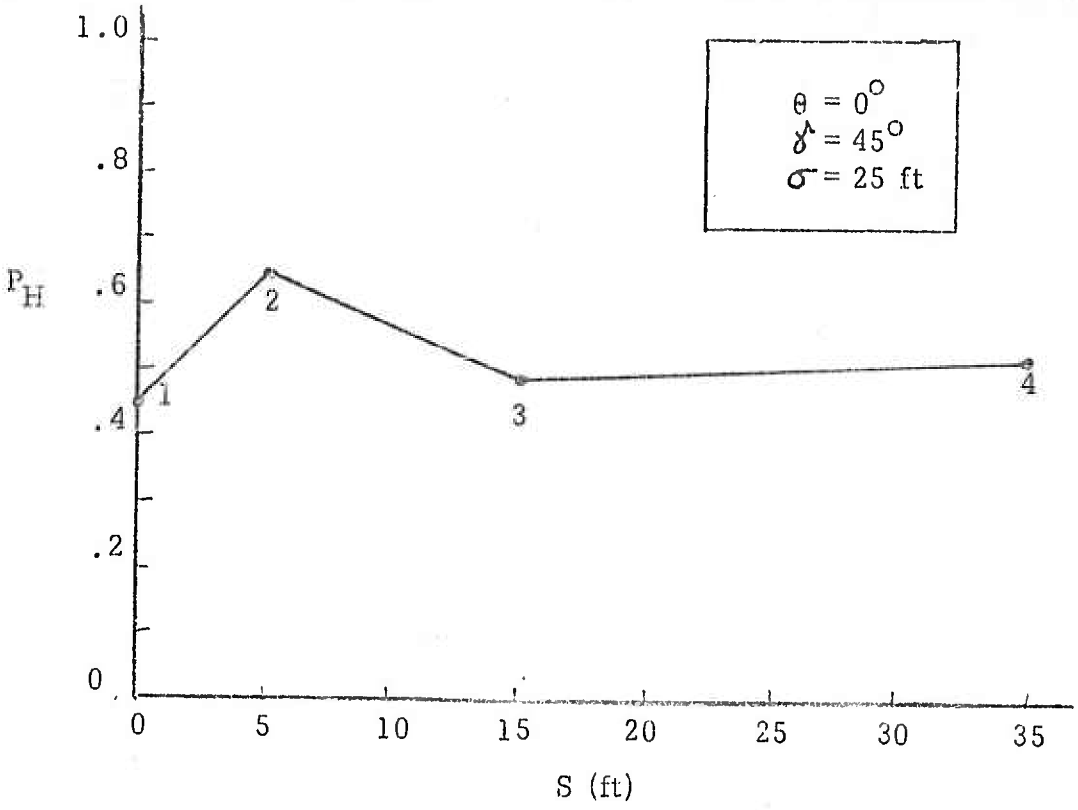


Figure 47: Variation of P_H with Aimpoint

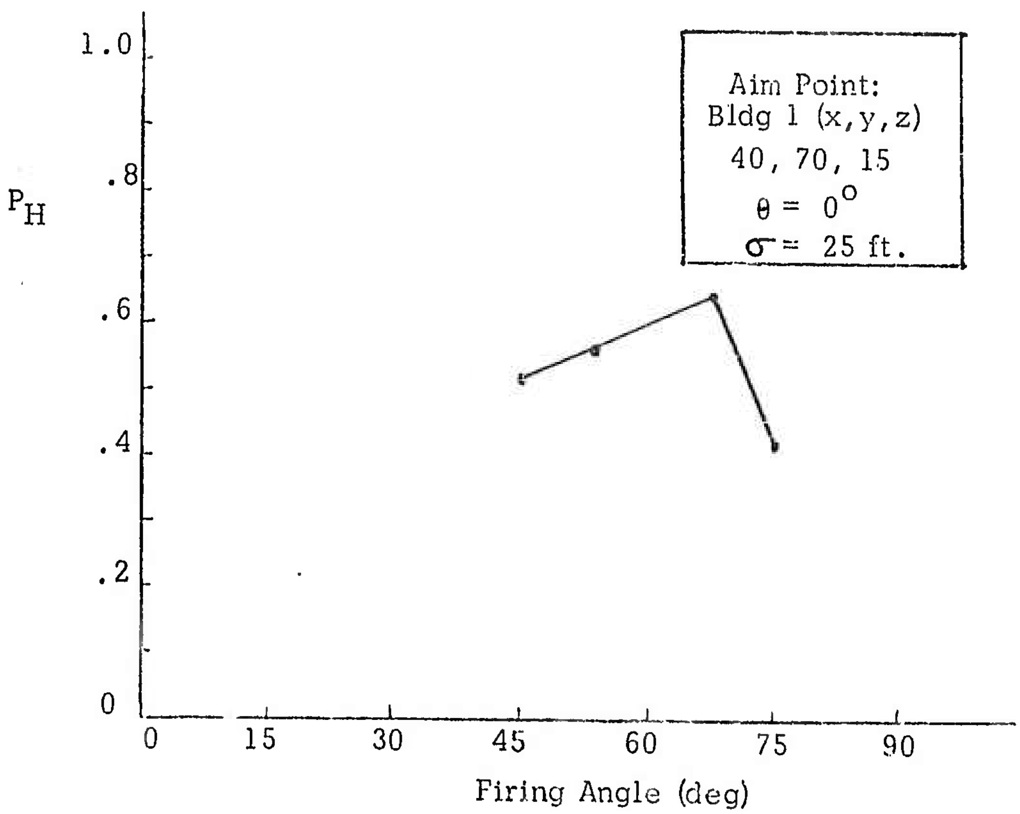


Figure 48: Variation of P_H with Firing Angle

where A_W = wall area

A_R = roof area.

The area, A is maximum when

$$\tan \vartheta = A_R / A_W .$$

Since $A_R = 40 \times L$, and $A_W = 15 \times L$ where L is the building length, then $\tan \vartheta = 40/15$, and $\vartheta = 68.7^{\circ}$.

(9) <u>Precision Guided Munitions -- Findings and Recommendations</u>

(i) Precision Guided Munitions have the potential to provide effective firepower in an indirect mode, but detailed knowledge regarding the applicability of PGMs in an urban environment is not adequate.

(i) A methodology for evaluating PGM performance in urban environments has been outlined in this analysis. Further development and application of the methodology is recommended to determine the combat utility of this asset vis-a-vis conventional munitions for selected specific attack and defense missions.

(ii) A PGM with a CEP of 25 ft or less will cause negligible collateral damage. Collateral damage accelerates rapidly as CEP is increased beyond this.

(ii) A 25 ft CEP should be the design goal for PGMs to be used in city combat.

IV.3.5 Off-Route and Scatterable Mines

(1) Current Capability - Off-route and scatterable mines specifically adapted to the urban environment do not exist in the current inventory. Present inventory items require concealment and camouflage techniques that make emplacement and effective use difficult.

(2) Environmental Characteristics - The steep and narrow and regular and trafficable canyons of built-up areas characterize it more than any other terrain feature with respect to land combat. In the defense opportunities are numerous for employing these ground movement channels advantageously for passive and active barriers or area denial systems.

Due to the prevalence of very short range engagement opportunities and highly channeled, a low-cost, low-performance off-route mine system offers promise of exceptional cost-benefit advantages in urban applications. The reduced effective range requirement can be exploited to minimize needed ballistic and warhead performance, and the close quarters engagement will simplify the sensor systems and its logic.

(3) Functional Area Interface - There are some functional area interface considerations which should be addressed when assessing the potential of new mines for city use. Mines emplaced in areas of high density population and traffic must be removable or in some manner made safe with a minimum of effort. The mines become liabilities rather than assets once the fighting is over. At least three methods of providing for safe operations have been considered. These are sensor discrimination, time window operation, and command detonation. The most foolproof is command detonation but this mode requires an on duty operator who in turn is vulnerable.

The use of the other two operating modes in combination with each other may be the answer to the control problem. All three modes should be considered.

(4) Concepts of Employment - Analysis of the scenario situations indicates that mine barriers would be extremely valuable to the defender as a means of placing additional constraints on movement and mobility of the attacker. Denying the use of specific avenues of approach with a minimum of resources permits the defender to use maximum force in areas of his choosing. This permits the defender to determine to some extent where the battles will be fought by denying the attacker easy access to specific areas.

Another tactic is to emplace mines as the defender falls back. The mines are to be command detonated at the approximate time. Further, area denial was found to be a problem, particularly in difficult to reach places such as sewers. Fuel-air explosives (FAX) devices and advanced techniques for plastic explosives may be useful in denying these routes of approach to the enemy.

Current inventory items are not suited to these tasks. Our analyses indicated a need for additional exploration of the following areas in the peculiar environments of built-up areas:

Off-route mines of low performance and low cost

Application of scatterable mines

Application of controllable mines

Mine emplacement and concealment techniques

Discussion with representatives of user and developer agencies confirm the need for (and lack of) such investigations.

The difficulty of concealing current mines on city streets further suggests that an improvement in this battlefield component is required. The placement of mines and boobytraps in automobiles,

by hydrants, or in windows or buildings for command or sensor triggered detonation appears to require improvements over their present configurations.

(5) Technical Feasibility - Some work has been done on both scatterable mines and off-route mines. The RAC study on scatterable mines attests to their technical and operational feasibility and reports on their effectiveness in the rural environment. The problems associated with city use have not been addressed, although no technical problems are envisioned.

According to information obtained through interviews with Israeli sources, an unsophisticated version of off-route mines were used by the Arabs in the defense of Jerusalem. The swiftness of the Israeli penetration forstalled their use as a barrier system to armored vehicles. The major difficulty was an effective means of positioning the system.

The problems that should be addressed are:

Controlled detonation techniques

Concealment and camouflage

Distribution procedures

Configuration

(6) Off-Route and Scatterable Mines -- Findings and Recommendations

(i) The current inventory of mines is not suitable for use in the city. Both off-route and scatterable mines would assist in controlling specific areas, canalizing the movement of enemy forces and slowing the rate of enemy advance. These new concepts appear to be technically feasible and cost effective for use in urban combat.

(i) The feasibility and tactical utility of scatterable and off-route mines have been indicated in the analysis of given scenarios. A detailed, rigorous study is recommended to evolve concepts of employment and materiel design goals.

IV.3.6 Smoke

(1) Current Capability - The infantry unit has many options for applying smoke to the battlefield. Within the unit, covering smoke (as opposed smoke to spotting rounds) can be delivered via hand grenade, smokepot, and mortar. WP is available for the 106 mm RR. From outside the unit, smoke can be delivered by heavy mortar and artillery. In most cases this current capability is not adequate for city combat. The precision required in delivering smoke in a street fighting situation is very stringent and consequently difficult to achieve via indirect fire. By hand it is difficult to deliver the amounts required to maintain the density and persistency required.

Detailed scenario analysis indicates that effective smoke systems will reduce casualties among attacking forces. Men moving in open areas are extremely vulnerable. Data collected at the Infantry Board have been used to compute M16 hit probabilities against moving targets. The resulting equation is: $P_h = .381\, e^{-.00623 \cdot \text{Range}}$.

The resulting curve showing hit probability as a function of range is shown in Figure 49. These values are for targets moving in a crouched position at 8 mph over an 80 foot open area without covering fire. Assuming that each of twelve squad members are exposed (50 meter range) to groups of six to two firers at least once in a daylong battle, the number of squad casualties can be estimated at one casualty. The use of smoke for additional cover would have the effect of changing enemy small arms fire from aimed to area fire -- reducing casualties significantly -- possibly by a factor of 10.

(2) Environmental Characteristics - Analysis of street fighting situations and interviews with the Hue commanders confirmed the importance of neutralizing the defender's superior position in urban combat. His almost infinite choice of prepared defensive positions with coordinated protective fire is a tremendous obstacle to the attacking force.

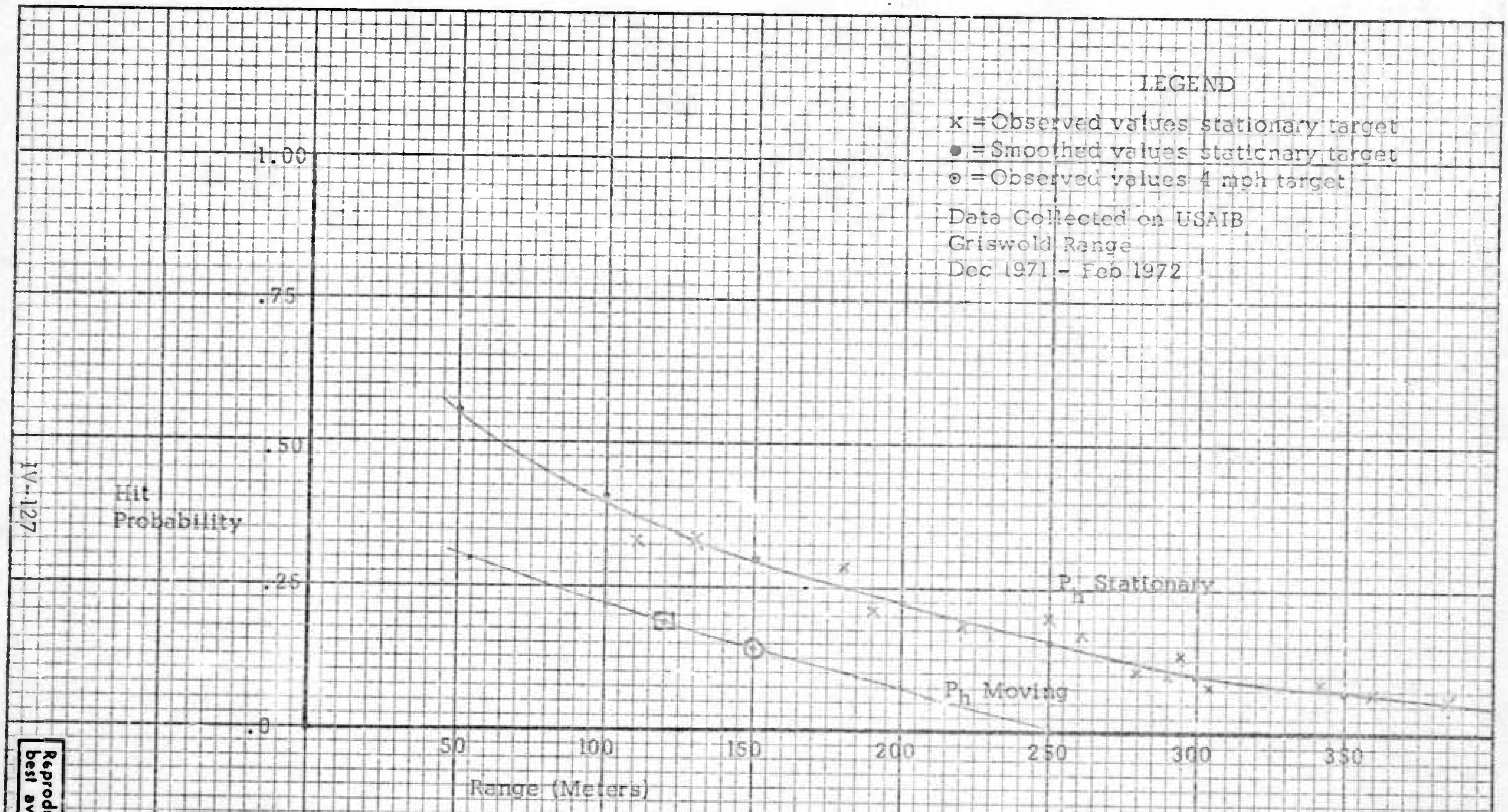


Figure 49. ESTIMATED OPERATIONAL HIT PROBABILITY FOR THE M16 RIFLE IN THE DEFENSE ROLE

The Hue commanders verified the conclusions reached in the scenario analyses: that movement through the streets during a firefight is almost impossible for the attacking force. Almost all movement in Hue was confined to the buildings themselves, using mouseholes to reach desirable covering positions from which short dashes across streets and alleys under intense covering fire could be made. Smoke and CS were used extensively in an effort to neutralize the defenders positional advantage. CS was used for as long as ten hours at a time. Observations of the effectiveness of current inventory items supported the conclusions reached above : that persistency and density were lacking mainly because the desired quantities could not be delivered. GEN. S.L.A. Marshall, in his publication, Notes on Urban Warfare, stated that new delivery means for use in urban areas is definitely needed.

(3) Functional Area Interface - The problem of delivering the amount of smoke required in a prolonged firefight suggests a system too large for individual use. Consequently, Mobility becomes a definite factor. A special smoke carrying vehicle or an adapter kit for current vehicles may be necessary to provide the quantity sufficient to produce the persistency and density required.

(4) Concepts of Employment - Smoke is typically used in attack situations when a positional advantage favors the enemy. Combat acitons where smoke is normally employed include:

Entering a city

Attacking strongholds

Breaching barriers

Crossing open areas

Attacking airport defenses

Building to building fighting

Smoke provides cover for movement of friendly forces -- reducing the time that friendly forces are vulnerable to aimed fire from the defenders. Smoke can be dropped, delivered by indirect and direct fire heavy weapons, or can be hand thrown.

Current munitions are adequate for screening large open areas using indirect or air dropped munitions. Such a barrage is normally applied just prior to movement from the line-of-departure. The smoke barrage follows the artillery preparation against the defensive positions and is designed to shield attackers as they move across the open area to the defensive positions. Smoke is lifted after the attackers gain a foothold in the defended area. At this time, localized areas require continuous smoke until adequate firepower is available to neutralize strongpoints. It is during this streetfighting close combat action that current systems fall short of requirements.

(5) New Concept - The desired support could possibly be provided with adaptors for current vehicles or specially designed vehicles. A preliminary concept would consist of a wheeled armored vehicle towing a rolling liquid transporter. Further study is necessary to complete the system design and to develop a liquid agent.

Several small engagement models could be used to estimate persistency requirements in terms of desirable heights, times, and densities. The capabilities of current munitions should be determined from test reports and by interviews with military personnel who have used these munitions in combat. Shortcomings should be identified through direct comparisons between actual and desired characteristics. Delivery means via sprays and conventional weapon projectiles should be reviewed for adequacy and specific improvement recommendations.

The output of this subtask which will be completed during the next contract year will include specifications for smoke irritant munitions in terms of dissemination and persistence characteristics, assessment of current munitions in fulfilling the requirements for smoke and irritant delivery, and new delivery concepts.

(6) Smoke -- Findings and Recommendations

(i) Smoke and other chemicals capable of providing concealment are of extreme importance in urban combat. Experience indicates that the current capability for providing smoke is not sufficient in terms of delivery means and concealment effects.

(i) Experiments should be undertaken to measure the performance characteristics of delivery systems in representative urban environments. This should then be used in the context of stated scenarios as a basis for developing new performance criteria and design goals for smoke munitions and dispensing systems. Preliminary studies should be undertaken for design of a vehicular mounted system to provide the quantities of smoke required.

IV.4 Infantry Tactical Concepts

IV.4.1 Urban Reconnaissance Patrols

The analysis of the scenarios provided by GTE Sylvania has served as a stimulus for consideration of the role and mission of reconnaissance patrols for combat in built-up areas. In contrast to real historical practice, the scenarios give overriding importance to the minimization of noncombatant casualties and the reduction of collateral damage. The conclusions from historical study bear out the belief that two large forces slugging it out in an urban area will of necessity cause wide spread destruction. Good reconnaissance capability will not only lessen the amount of damage done to the built-up area but will also minimize the chance that friendly forces will be destroyed by the enemy. This is the main purpose of having good reconnaissance.

A perusal of pertinent literature on the subject of urban reconnaissance patrolling has produced no useful findings. Initially it was thought that some of the materials from the Small Independent Action Force Studies* would be relevant but these models were far too complicated to be employed under the scope of the present study area. In addition, a literature search of SIAF models indicated what might have been expected, that all of the models were based on open terrain far from any man-made structures. Present results are thus based on the use of scenarios, historical analysis, and detailed discussions with field commanders. It is felt that greater effort should be concentrated on quantitative aspects of urban patrolling in future work. Rapid completion of mission and minimization of collateral damage appear to be the key mission variables for future U.S. and U.S. supported

*Vertex Corp., "SIAF Models, "The Results of a Literature Search".

missions in built-up areas. Both of these variables can be controlled to a much greater degree through better use of patrolling techniques and equipment. Few other areas identified in the MOBA study seem to be capable of making such significant improvements in these two key areas.

The weakness of the current qualitative type of analysis lies mainly in the inability to formulate and describe the equipment mix issue. A given force on patrol in a built-up area with a particular set of high performance equipment (including weapons) may be significantly inferior to a patrol that has equipment with relatively less performance but that has a different mix of equipment. Scenarios, though nonquantitative, serve as a useful baseline for constructing mission lists and catalogs of likely targets. Urban reconnaissance patrols (URPs) are used by various countries and different doctrinal concepts and shades of emphasis have developed. An overview of these different concepts is useful for the purposes of problem definition and generation of new ideas and tactical variations.

(1) United States - Army doctrine for urban patrolling is contained in Intelligence Handbook by the Army Infantry School at Fort Benning (ST 7-151 FY 72). Because of the brevity of treatment, the section is reproduced in this report (Table 16).

This piece is more important for what it does not say than what it does. Historically, U.S. intelligence in recent combat actions in cities is about as bad as it could possibly be. There was little or no warning that enemy troops had infiltrated Hue in 1968. Thus the main response to reports of conflict in the city was to send two Marine battalions into the built-up area. Although no exact numbers are available, it is accepted that they were outnumbered. Being

67. BUILT-UP AREAS.

a. General. The intelligence aspects concerning operations in built-up areas contrast sharply with other environmental conditions previously discussed. Terrain analysis is still important to both forces; however, there is normally a greater amount of information available. Most inhabited areas have been planned and laid out from some sort of blueprint or diagram. The normal large scale of these documents makes them ideally suited for analyzing the terrain. The presence or absence and attitude of the inhabitants is significant. The habitants may have been evacuated. However, if they have gone underground or return during or after the conduct of an operation, they will pose serious control and security problems. The "other" characteristics of the area, i.e., political, sociological and psychological, may be of greater significance and therefore must also be given careful consideration.

b. Weather. Weather will have the usual effect on visibility but little effect on trafficability, men and equipment.

c. Terrain.

(1) Observation and Fire. Observation and fields of fire are limited to narrow lanes provided by streets and alleys. Restricted observation also reduces the effectiveness of observed indirect fire. Because of these restrictions, increased emphasis is placed on seizing tall structures for use as OPs. However, the advantage afforded the ground observer (especially at basement level) should not be overlooked particularly during periods of intense fighting when the smoke is the most dense. This smoke would limit observation from tall buildings.

(2) Concealment and Cover. Built-up areas afford excellent concealment and cover for both forces. However, the defender has a distinct advantage in that the attacker must expose himself to move through the area. For this reason, the attacker avoids the streets and passes from building to building, through sewers, tunnels, or blasts from basement to basement. The effectiveness of cover depends on the density of the building construction. Wooden buildings which provide excellent concealment offer little cover and are reduced to rubble or set afire very easily. Stone or masonry buildings with thick walls offer excellent concealment and cover and normally the more shelling and rubble produced, the better the cover afforded.

(3) Obstacles. The area is in itself an obstacle. Rubble and debris, created as a result of shelling and bombardment, present additional obstacles to movement in streets and alleys.

(4) Key Terrain. Initially, in the attack of a built-up area, key terrain consists of those features that dominate or control the approaches in the area. Once these features are seized, other features such as strongly constructed buildings, which cover favorable avenues of approach, hubs of underground sewage and subway systems, communication facilities, and public utilities (water, light, etc.) become key terrain. Tall structures that provide an advantage in good observation may be key terrain.

(5) Avenues of Approach. The best avenues of approach will normally be underground passageways, through buildings, gaps between buildings and alleys. The streets and roof tops will normally be covered by fires and consequently constitute the least desirable of all approaches.

d. Reconnaissance. Great quantities of information are normally available concerning major built-up areas and the intelligence officer's major task is sorting and selecting the most important and up-to-date information. In general, ground reconnaissance procedures and techniques complemented by aerial reconnaissance will be very similar to those described in the discussion of fortified areas.

Table 16: U.S. Army Doctrine for Urban Patrolling

outnumbered in the open is sometimes acceptable, but being outnumbered when the mission is to assault, clear, and seize a built-up area is a violation of the most fundamental military principles. It appears that throughout the house-to-house fighting in the city there were no reconnaissance patrols used. It is fortunate that NVA did not launch any major counterattacks for there apparently would have been little or no warning. An account of urban combat from Marshall Chuikov at Stalingrad to the recent combat in built-up areas study done at Fort Benning agrees that the only way to defend a city is to use an active defense. Quick counterattacks must be be launched if key terrain features are to be held. The fact that the NVA in Hue did not follow this principle should not lessen the importance of reconnaissance patrolling. Good detection of enemy firing positions in pulverized buildings would substantially increase the advance rate through a city. In most cases a high advance rate will cause less collateral damage than a lengthy block-by-block slugging match. There is a current tendency for U.S. forces to advance through a built-up area until resistance is met, at which time the entire battalion is stopped. Only with the destruction of the enemy strongpoint in question can the battalion move on. In Hue tanks were not used in a recon fire mission. They usually advanced slowly down streets and into intersections ahead or beside the infantry. Detection of enemy positions was by actually drawing fire, and it should be noted that this fire(usually in the form of B40 rockets) was fired onto a tank that was moving very slowly. When strongpoints were encountered the armor was maneuvered into improved firing positions so that the target could be promptly destroyed. This appears to be a key difference in tactical employment of armor in cities compared with Soviet doctrine and experience.

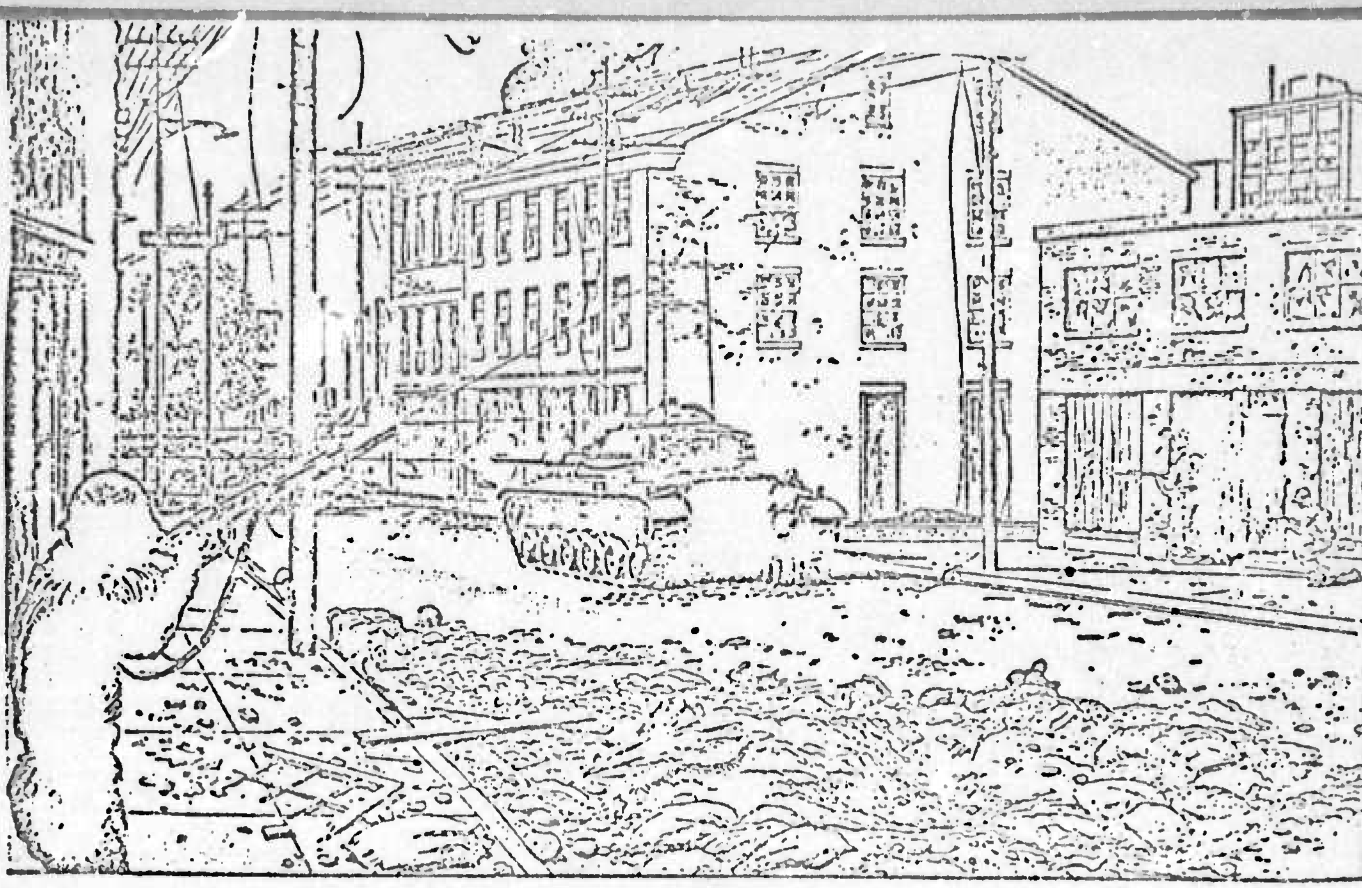
A tank may be able to expose itself for brief periods of time if it is moving quickly with less chance of destruction than dismounted infantry. Yet little thought appears to have been given to the role of tanks serving as the backbone of a fighting reconnaissance force for combat in built-up areas. A brief look at the doctrine for armor in cities shows that reconnaissance is apparently not one of their missions:

Mission of Tanks in Street Fighting*

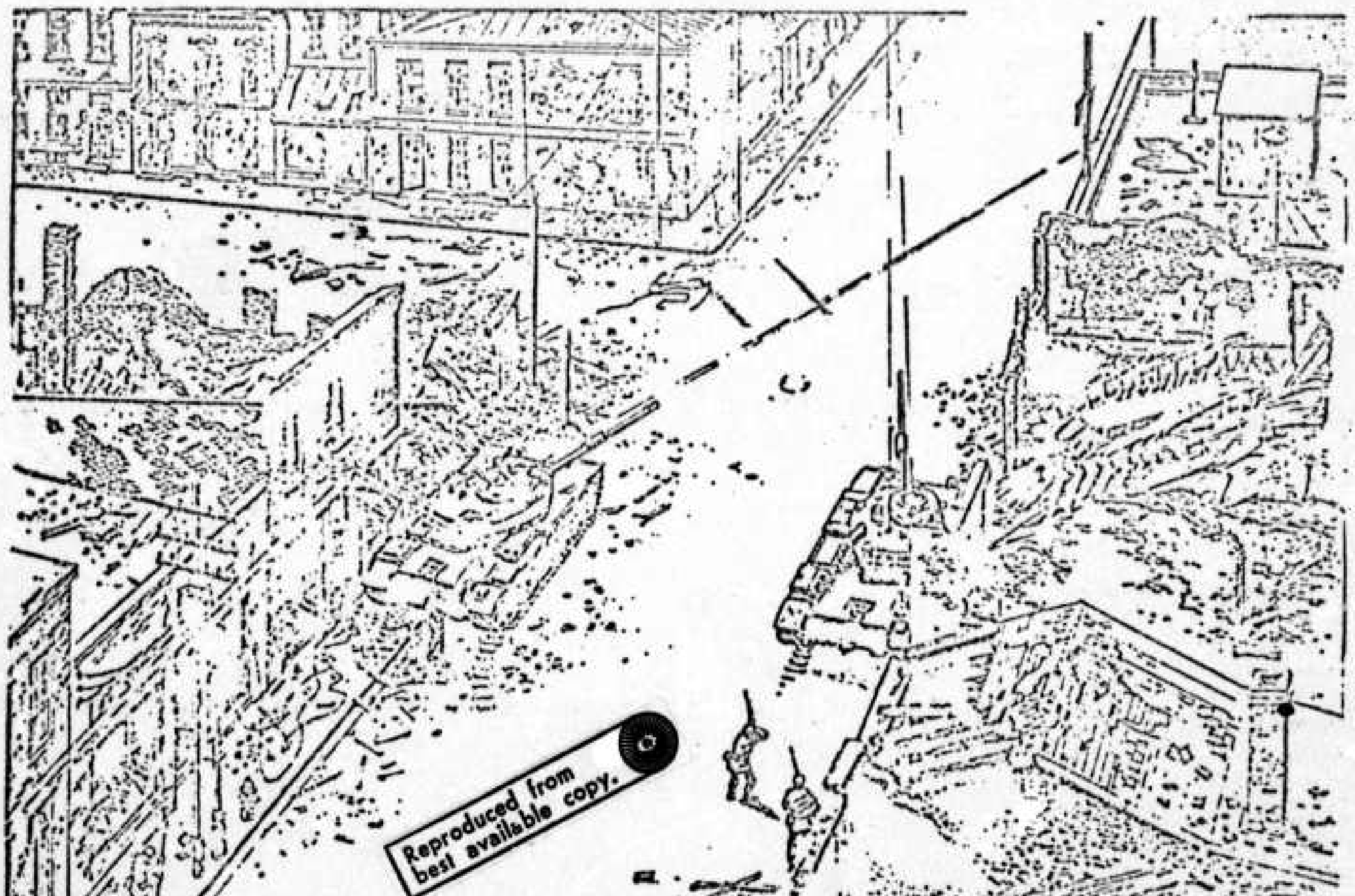
a. Neutralization of enemy positions by machinegun fire to allow the mechanized infantry to close with and destroy the enemy.
b. Destruction of enemy strongpoints by appropriate tank fire.
c. Destruction of barricades across streets.
d. Forcing of entry for infantry into buildings when doorways are blocked by debris, obstacles or enemy fire.
e. Taking under fire any other targets indicated by the mechanized infantry (Fig. 50).
f. Establishment of roadblocks and barricades.

It is interesting to consult the accompanying figures in the Armor Operations Field Manual to ascertain the proper use of tanks in built-up areas. These figures are shown in Figure 50. Consulting again with the Intelligence Handbook of the Infantry School, (2) Concealment and Cover, we find "For this reason the attacker avoids the streets and passes from building to building through sewers, tunnels or blasts from basement to basement." The position of the soldiers in the figure from the Army FM is thus out of line with infantry doctrine. From interviews with field commanders and historical research, it is evident that streets are usually certain death for dismounted infantry. Since tanks, and to some extent armored personnel carriers are the only systems that can be used against intense short range small arms fire, these systems ought to be considered as the basis for composition of fighting recon patrols.

* From "Armor Operations" Dept. of the Army Field Manual, FM 17-1, p.285.



Tanks take under fire targets indicated by dismounted mechanized infantry.



Movement of tanks

Figure 50: Examples of Armor Operations

U.S. experience in Santo Domingo (1965) revealed that "great quantities of information" on the city were supposedly available to those planning the operation. Such information would have been most helpful for members of reconnaissance patrols. For example, knowing that it is safest to penetrate enemy lines by using "sewers, tunnels" and other passageways does little good (for foot patrols) if one does not know the location of these sewers and tunnels. As it turned out, the "great quantity of information" was actually available to planners only in a theoretical sense. Little, if any information on Santo Domingo was available directly. Valuable time was lost as DIA channels had to track down the original plans of the sewage system of Santo Domingo from the original U.S. builders. Item (d) from the Intelligence Handbook could thus be very misleading to a field commander if taken literally. Historical experience and interviews with field commanders (from Hue and Santo Domingo) indicate that little of the information available is usable and that most information needed is not on hand, especially during the early stages of the operation when planning is most important.

(2) USSR - Soviet ground forces place much greater emphasis on the role and use of reconnaissance patrols in built-up areas than the United States. Analysis of their doctrine reveals that they divide reconnaissance into independent, specialized categories. For example, engineer battalions will tend to rely on engineer reconnaissance units and infantry will rely on infantry reconnaissance. This may or may not lead to problems at higher levels for information transfer, but it does show that great value is placed on this mission. Their methods are more redundant than U.S. methods, and hence more costly, but they seem to feel that this emphasis will pay off in the long run. It is quite difficult to dispute this contention if one compares the

first few days of the Santo Domingo Operations with Prague Operation in 1968. While the U.S. was about to air drop a division of supplies onto a coral reef, the Soviets had thoroughly cased out the Ruyzne airport in suburban Prague. Though detailed accounts of this preliminary surveillance are not available, account of the operation itself has been reviewed. This information is presented here to demonstrate the detailed nature of Soviet planning. Without giving any moral opinions about the operation, it is nevertheless true that on an August night in 1968, the Czechs and the Slovaks had their country stolen from them. A good part of the reason for the success of this theft was the result of detailed planning of troop deployment in built-up areas. The account of the action follows:

> Ruzyne Airport, Prague, on a drab plateau seven miles from the city centre, is like most international airports in Central Europe. During the daylight hours its runways are congested as inter-city jets carry businessmen, politicians and engineers from capital to capital. At night there is a relative calm, and the chilly evening of August 20 was no exception. An Ilyushin from the Polish airline LOT taxied away and lumbered off into the night heading for Warsaw. The Czech traffic controllers in the tower relaxed; the next scheduled flight, bound for Ankara, was not due for three hours—after midnight; but at ten-thirty a heavy Russian Antonov civil airplane was expected, by special arrangement with Aeroflot, the Soviet airline. This was not particularly surprising to the airport officials, for the same plane had come to Prague the day before under a similar arrangement. On the stroke of ten-thirty the AN24 heaved down from the sky and rolled to a standstill beside the terminal building. A group of men, some in Russian Army uniform, clambered down, strode to waiting cars, and drove off. There was nothing exceptional in that.

Meanwhile in the tatty departure lounge of the terminal building a group of men with holiday gear were slouched in the chairs, smoking heavily and sipping dark coffee, as a cleaner swept the floor around them. They were apparently awaiting the flight to Turkey. Suddenly they all stood up together, took revolvers from their pockets, left two men on guard and disappeared. At this point a number of Russian Volga cars roared up and screeched to a standstill. Their occupants got out, marched quickly back to the stationary AN24 parked on the apron, and went inside it. This was a surprise to the traffic controllers, who had not expected the Russian aircraft to take off until the next morning, but hardly had their surprise registered when their door opened and the 'tourists' who had been sitting in the departure lounge burst in, held them up at pistol point and ordered them to cease to man the radar and talkdown apparatus. As the Czech controllers wondered what was going on, another transporter descended from the pitch black sky, followed minute after minute by a constant stream of aircraft.

The truth at once dawned on the traffic controllers: the Soviet aircraft had been directed into Prague by a special crew operating electronic equipment in the AN24.

Then came the roar of fighters, as Russian MIGs, flying in close formation, screamed over the city, drawing late-night drinkers and dancers to hotel windows to watch. Minutes later Ruzyne Airport was completely under the control of the invaders, as still more planes droned in. Command headquarters were set up for Red Army General Pavlovsky, and infantrymen bearing torches in one hand and sub-machine-guns in the other marched in a long column towards the city. The men were mainly Asiatics, Kalmyk or Mongol, single-minded, brutal soldiers who are often used by the Soviet Army to carry out the more dangerous or unpleasant tasks. Many of them do not even speak Russian. Immediately behind them came tanks and armoured vehicles. As the heavy transports landed, other Red Army marines and parachutists were dropped in the Prague suburb of Sporilov alongside a new section of motorway. The tank columns which entered the city from the airport down the four-lane Lenin Highway split into three at the Square of the October Revolution in Deyvice on the outskirts of the city, one column going south to the Hradcany Palace while the largest column went eastwards to the Prime Minister's office and the third crossed the Vltava River at the Hlavek Bridge, where by 4.30 a.m. several

dozen Russian tanks surrounded the Central Committee headquarters. The tanks rumbled across the bridge over the Vltava River and into Wenceslas Square, where engineers had been building a pedestrian subway and so the centre was closed except to trams. But the Russians ignored the signs and rushed straight in. The infantrymen spread out and secured key installations: the crucial bridges over the Vltava; the main roads. It was a model operation, conducted with remorseless efficiency.

It was the same story all over the country. Polish MIGs arrived to set up a base at Tardubice Airfield, forty miles from Prague, and at other military airports all over the country. Sometimes the MIGs came before the troop-carrying transporters. At Hradec Kralove, in north-east Bohemia, a lone MIG15 touched down, a high-ranking Russian officer climbed out, refused to give his name, and would not state the reason for his arrival. The reason became apparent to the base commanding officer later in the day when forty other MIGs had landed, followed by helicopters carrying Russian and Polish soldiers. And, as the aircraft flew in, Moscow gave the orders to ground forces waiting behind the borders of Czechoslovakia to invade. Across they came—into the orchards of Bohemia, into Slovakia from Hungary, into the northern industrial city of Ostrava. The tanks smashed down anything that stood in their way—telegraph poles, trees, even cars parked in the streets. In the east, heavy transport from the Ukraine crossed the frontier. By dawn the first land-bound troops had reached Prague, and joined forces with the élite group of specially trained commandos which had taken Ruzyne Airport. There was no resistance; there could not be. And at 1.10 a.m. on Wednesday, August 21, came this announcement from Prague Radio:

'To the entire people of the Czechoslovak Socialist Republic.

'Yesterday, on August 20, at about 2300, troops of the Soviet Union, the Polish People's Republic, the German Democratic Republic [East Germany], the Hungarian People's Republic and the Bulgarian People's Republic, crossed the frontiers of the Czechoslovak Socialist Republic. This happened without the knowledge of the President of the Republic, the Chairman of the National Assembly, the Prime Minister, or the First Secretary of the Czechoslovak Communist Party Central Committee. In the evening hours the Praesidium of the Czechoslovak Communist Party Central Committee had held a session and discussed preparations for the Fourteenth Czechoslovak Communist Party congress. The Czechoslovak Communist Party Central Committee Praesidium appeals to all citizens of our republic to maintain calm and not to offer resistance to the troops on the march. Our Army, security corps, and people's militia have not received the command to defend the country. The Czechoslovak Communist Party Central Committee Praesidium regard this act as contrary not only to the fundamental principles of relations between socialist states but also as contrary to the principles of international law.'

This smooth operation must have been based on lengtny reconnaissance of the city of Prague. The important point to note is the ability of Soviet units to get and use information about the city. This allows their advance street reconnaissance units to do more than act as units whose only purpose is to locate enemy positions by drawing fire on themselves.

At higher levels of conflict intensity a look at Soviet doctrine for battalion level units show that increased reconnaissance effort is listed as one of the six key differences between rural and city combat. Advance units have their own reconnaissance teams and are advised not to become involved in protracted combat. This advice probably derives from Soviet experience in assigning reinforcements to advanced assault units engaged in combat. As far as Soviet opinion on the matter is concerned, reinforcements cannot be successfully moved into a city in any reasonable period of time.

Soviet urban reconnaissance patrols move on foot for the most part. They place great stress on night operations and use of concealed penetration routes to the enemy's rear. These can be sewers, subway tunnels, gaps in buildings, and the like. Deep penetrations seem to be stressed as opposed to down the block locations of the enemy. Doctrine advises the use of men with several specialities (artillery men, sappers, snipers, chemical specialists, and so on) in order to get a more complete picture of the enemy.

Marshall Chuikov, the army commander at Stalingrad and later commander in chief of all Soviet land forces in the 1960s, describes a recon patrol dispatched against the Germans. He points out that special considerations must be given in employment because enemy units are of an extremely high density in city fighting. His experience is worth special consideration since it was gained

over five months in the same city. A particular patrol is described in more detail:

A Soviet Recon Patrol at Stalingrad

- 7 men in unit: 4 men in actual duty, 3 resting;
- Mission: Reach Vishnevya Gully and determine enemy concentration ;
- Equipment for the four men: 3 submachine guns, 12 hand grenades, 1 small bore rifle, 1 radio set, rations, medical supplies, 1 telephone apparatus.

We have not been able to determine the purpose of the telephone apparatus, perhaps it was to tap enemy wire or to communicate to friendly HQ by using existing telephone lines in the city. On this patrol a German prisoner was captured and interrogated. For this they used pencil and paper keeping the prisoner gagged because of the very close proximity of the enemy in the city.

(3) United Kingdom - U.K. Forces have gained much experience in urban patrols in the past few years through their involvement in Northern Ireland. In this severe urban guerilla situation they have relied heavily on foot patrols for intelligence gathering and wheeled armored vehicle for reconnaissance on guerilla positions when there is a danger of enemy fire. In addition, they have been using advance scouts ahead of patrols to detect quickly the exact location of any sniper fire on the patrol. These scouts usually operate from the tops of buildings adjacent to the street patrol. Small units also are employed to quickly break into houses that are suspected of being guerilla supply points. In it not unreasonable to consider these as falling under the role of urban patrol.

British foot patrols for intelligence gathering purposes almost always operate at night. They move single file on side streets and

are specially skilled in handling demolitions and protecting civilians. As with the other British troops stationed in Ireland, they wear protective flak jackets and helmets with plastic visors. When there is enemy fire or the threat of enemy fire, the British use scout vehicles, armored cars, and armored personnel carriers for short range patrols. Daily nightly patrols using armored vehicles in quiet areas is deemed provocative. The current armored vehicles in use in the cities of Northern Ireland are shown in the next three figures. It should be noted that rapid reinforcement is one of the main tactics used by patrols. This is in distinction to higher levels of conflict where some authorities feel that this is not possible.

(4) Israel - Israeli ground forces engaged in urban combat favor reconnaissance patrols that are based around the tank and APC. They view the use of the patrol as one of fighting reconnaissance. It is similar to the tactics used by the Soviets in Budapest in 1956, although such a use of armor is now discouraged by Soviet doctrine. Israelis feel that isolated foot patrols in built-up areas are too vulnerable to be of much use. This contrasts sharply with U.S. doctrine which apparently feels that armor should not be isolated in a city. Presumably, it is because the infantryman is felt to be less vulnerable than a tank.

In the Battle for Jerusalem in 1967, the Israelis had such a thorough knowledge of the city that the only important information needed were enemy troop dispositions. This was gotten by tank and APC recon patrols. The infantry stayed mounted in the APCs when on reconnaissance missions. These Israeli recon units apparently were free to penetrate and seize enemy strongpoints if the opportunity arose. As with Soviet doctrine and experience, the Israelis feel that it is difficult to quickly deploy reinforcements to front line units

The British Daimler Ferret Mark 4
(FV 711) Scout Car
Weight: 5.4 tons. *Crew:* 2.
Armament: one 7.62mm Browning machine-gun. *Armour:* 6mm minimum, 16mm maximum. *Engine:* one Rolls-Royce B60 6-cylinder inline, 129bhp.
Speed: 50mph. *Range:* 190 miles.
Length: 13 feet. *Height:* 6 feet 7½ inches.
Width: 6 feet 11½ inches

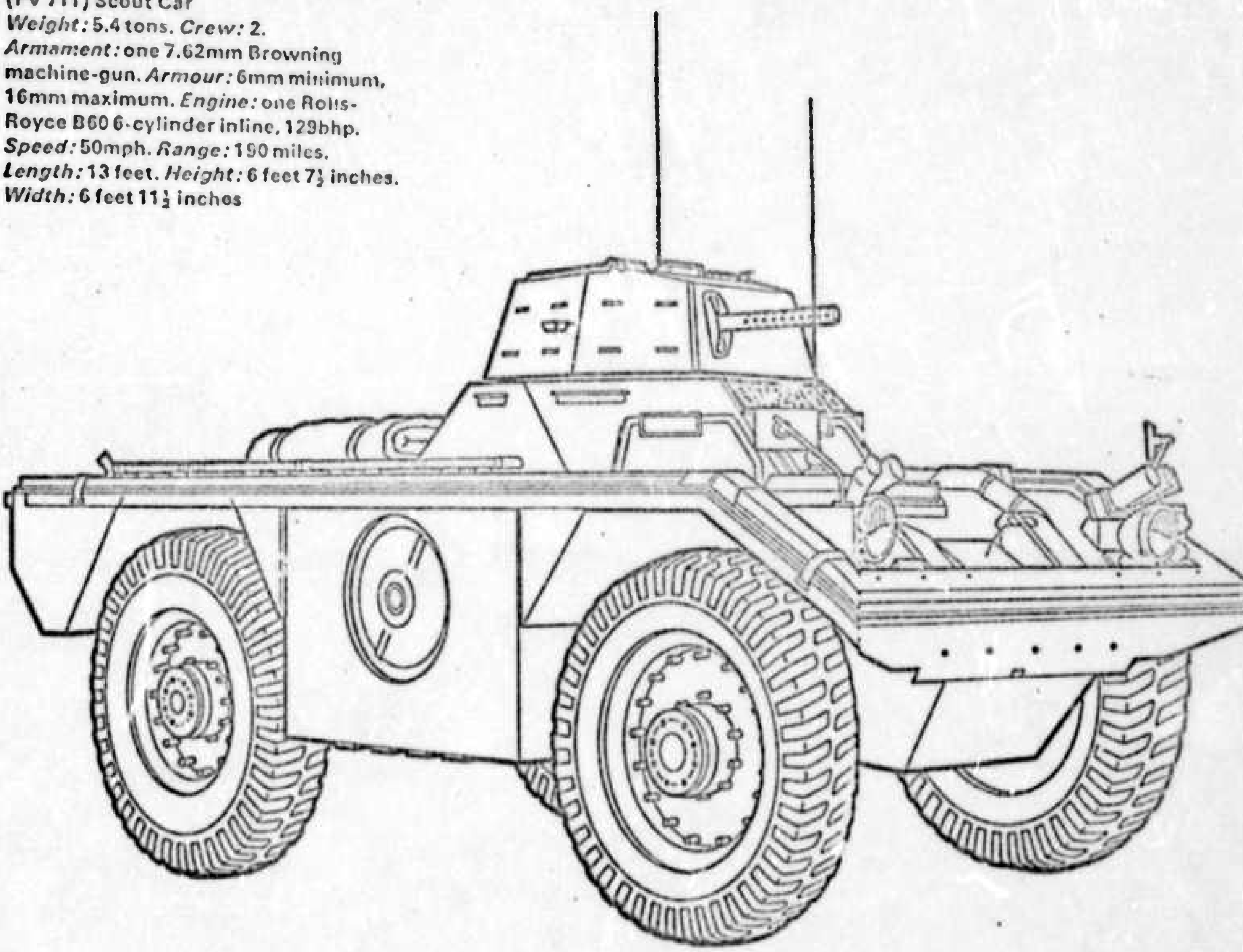


Figure 51: The Ferret Mark 4

The British Alvis Saladin Mark 2 (FV 601 (C)) Armoured Car
Weight: 11.4 tons. *Crew:* 3
Armament: one L5A1 76mm gun with 42 live and practice HESH, HE, Canister and Smoke shells, plus two .3-inch M1919A4 Browning machine-guns with 3,500 rounds. *Armour:* hull glacis 12mm, nose 14mm, sides and rear 16mm, roof 10 to 12mm, and floor 8 to 12mm; turret front 32mm, sides and rear 16mm, roof 10mm. *Engine:* one Rolls-Royce B80 No 1 Mk 6D 8-cylinder inline, 160bhp. *Speed:* 45½mph. *Range:* 250 miles on roads, 140 miles cross country. *Fording:* 3½ to 7 feet *Step:* 1½ feet. *Length:* 17 feet 4 inches *Height:* 7 feet 10 inches. *Width:* 8 feet 4 inches. *Trench:* 5 feet

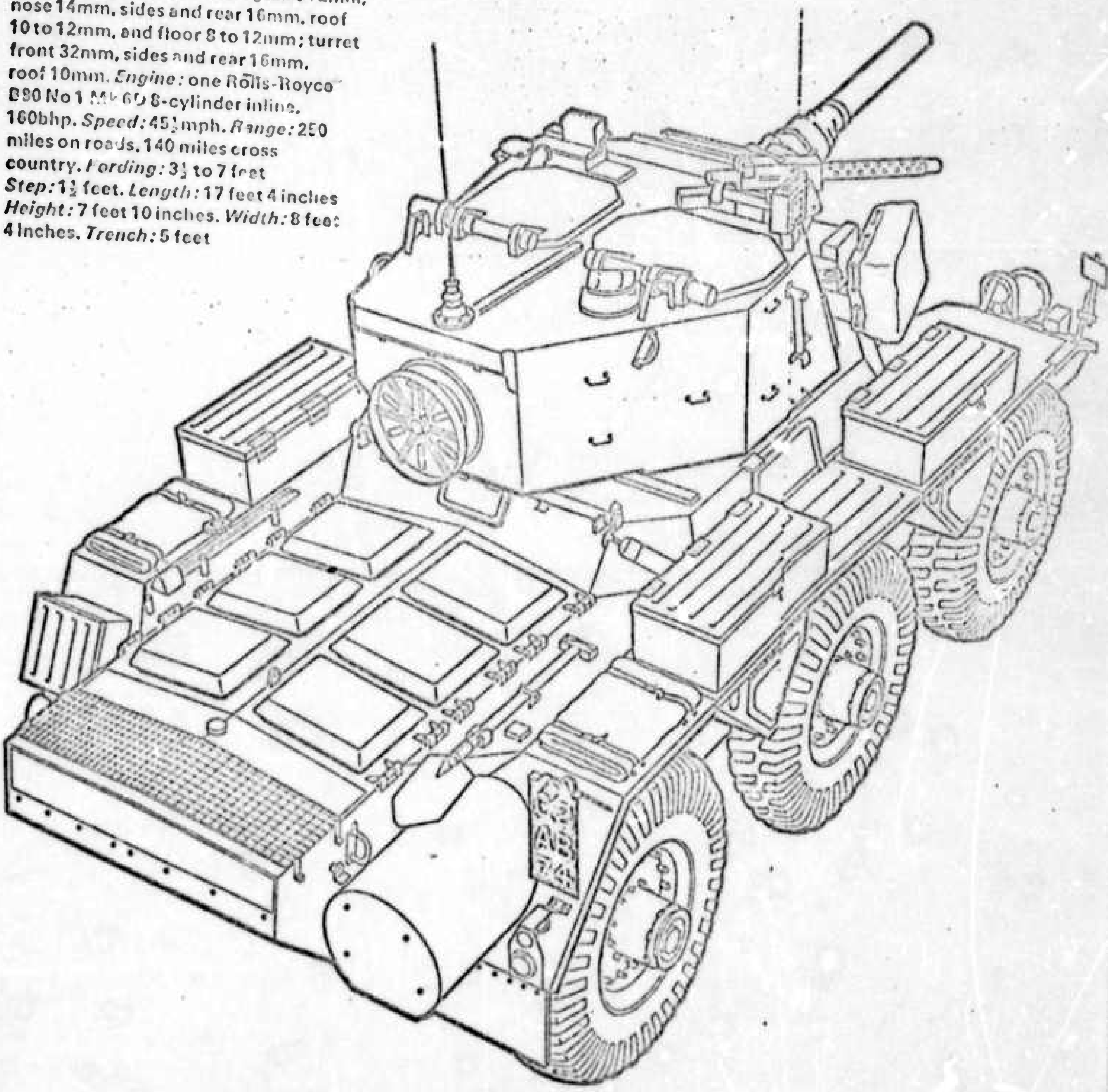
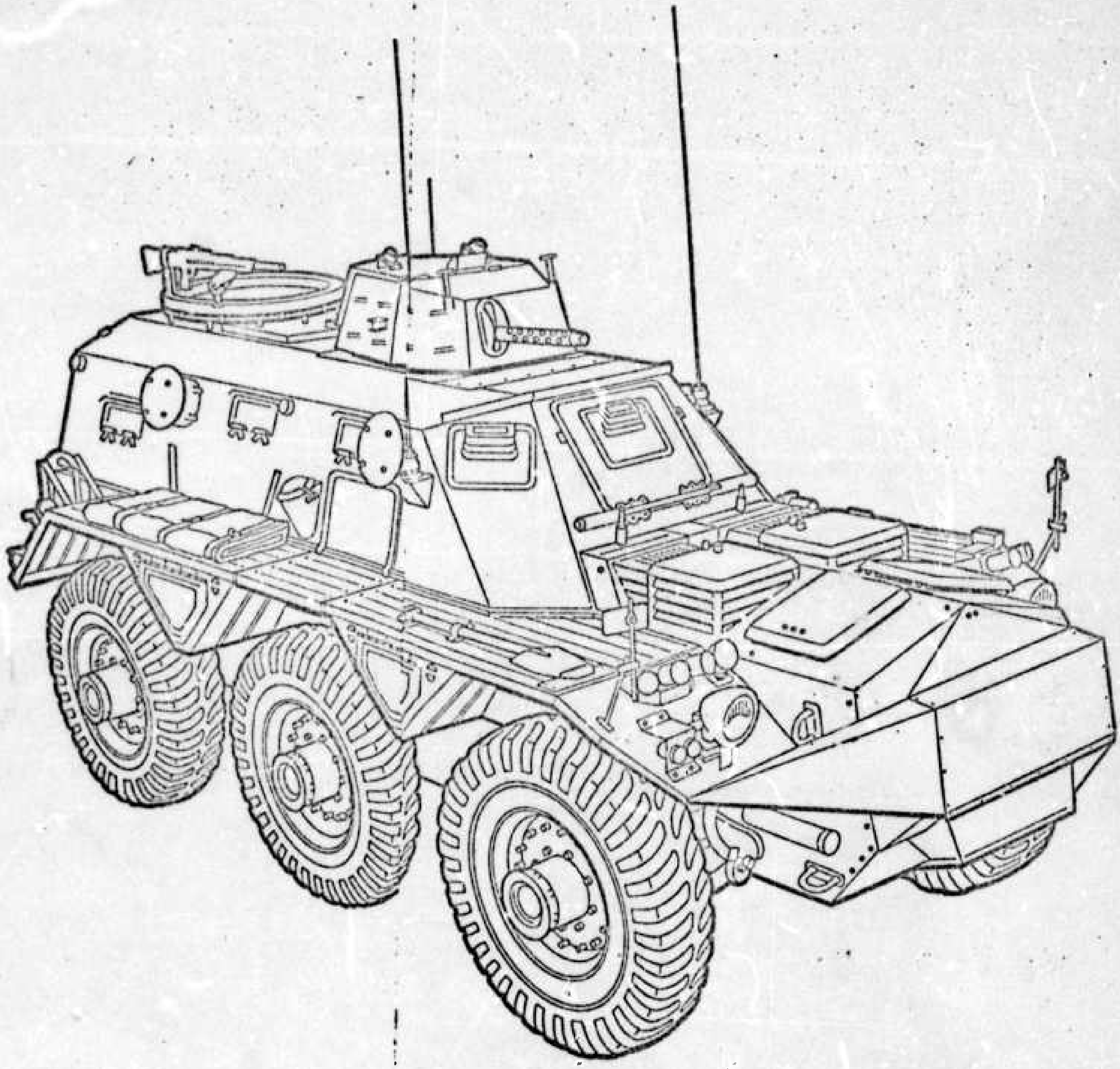


Figure 52: The Saladin Mark 2



The British Alvis Saracen (FV 603 (C)) Armoured Personnel Carrier *Weight:* 10.25 tons. *Crew:* 3 *Accommodation:* 9. *Armament:* one .3-inch Browning machine-gun with 3,000 rounds, plus the 7.62mm GPMG and eight SLRs of the infantry section carried. *Armour:* hull glacis 12mm, nose 10mm, sides 12mm, roof 8mm, and floor 12mm; turrent front 16mm, sides 1[illegible]mm, rear 8mm, and roof 8mm. *Engine:* one Rolls-Royce B80 8-cylinder inline, 1[illegible]0bhp. *Speed:* 45 mph. *Range:* 250 miles on roads and 140 miles cross country. *Fording:* 3½ to 6½ feet. *Step:* 1½ feet. *Trench:* 5 feet. *Length:* 17 feet 2 inches. *Height:* 8 feet 1 inch. *Width:* 8 feet 4 inches

Figure 53: The Saracen

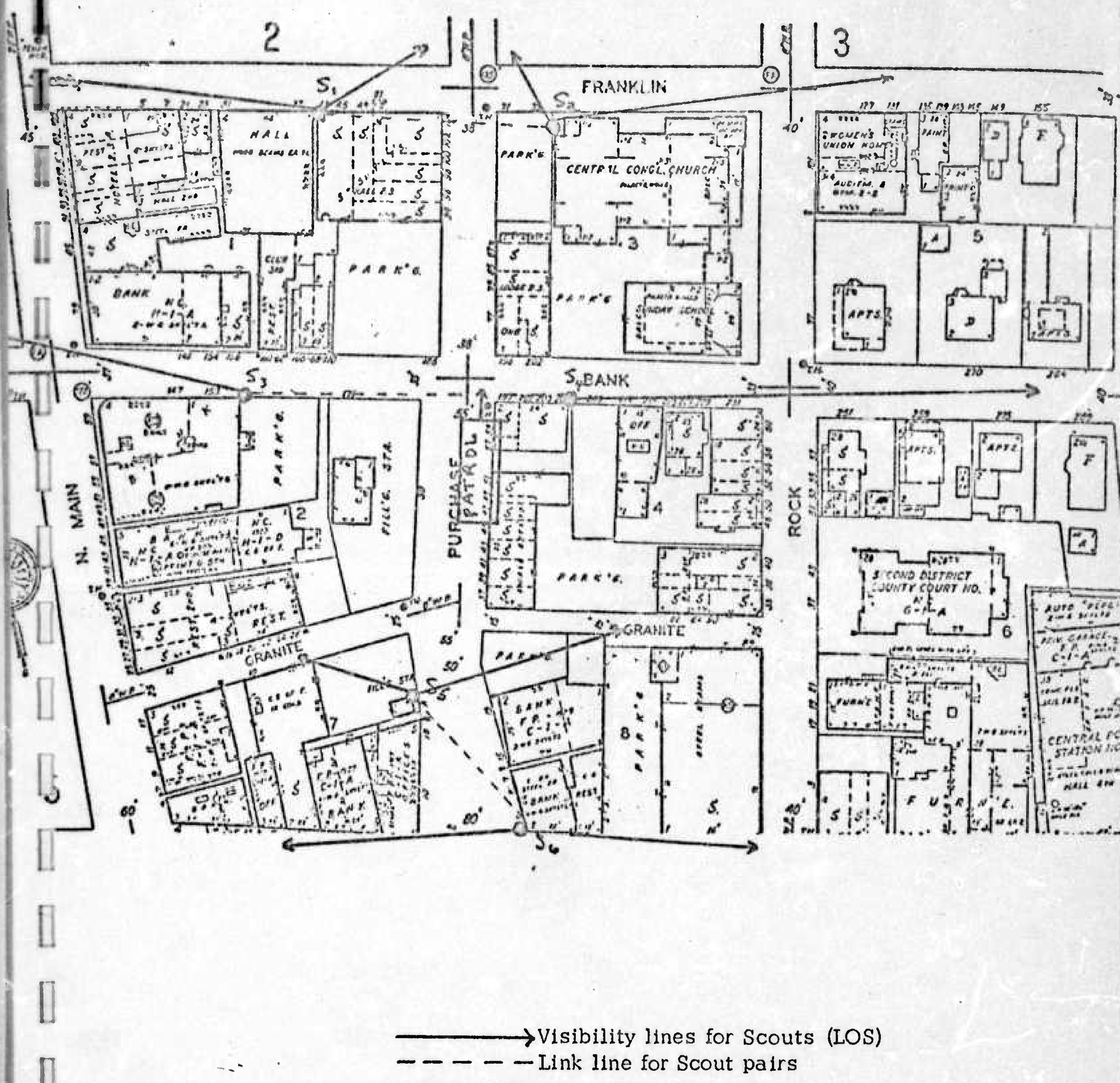
fighting in the city. This is reflected in the fact that they advise taking reserves into the city itself with the battle units.

(5) Summary - Although there are wide disparities on the use of urban reconnaissance patrols there does appear to be some conclusions that are capable of being backed up by the brief look at differences in views derived from experience.

- U.S. forces have considered the issue in only superficial form.
- Absolutely no use of surveillance, target acquisition and night observation (STANO) devices has been found in urban areas.
- The issue has not been split into a mission list for urban patrols.

(i) Missions of the Urban Reconnaissance Patrol - There are numerous missions for the urban patrol. These missions will be a decided influence on equipment that is carried and on deployment. For example, a fighting foot patrol will not be composed of only five men as the Soviet intelligence gathering patrol. The fighting foot patrol will also employ front, rear, and flank scouts to give the patrol a wider area of coverage. This is shown in figure 54. On the other hand, the fighting urban patrol that is armor based will not have scouts but will depend on the added speed of the vehicles to increase the area of coverage. In addition, armored patrols will be able to carry a greater load than a foot patrol.

(ii) Classification of patrols in built-up areas - This is necessary before any serious analysis can take place. Our methodology for the classification herein proposed is based on historical experience, military judgment, and interviews with participants in several urban conflicts.



———→ Visibility lines for Scouts (LOS)
– – – – – Link line for Scout pairs

Figure 54: Scout Deployment for Patrol Protection

It is not obvious how a match up between patrol type and mission could take place. Such a correlation depends on the doctrine, the particular situation and the personal preferences of the field commander.

It is believed that the present research on urban patrolling is sufficient to generate event conditions for a realistic range of actions. Application of already developed modeling techniques to examine in detail the tactics of appropriate patrols is recommended as small task in the next year's effort. Figure 55. summarizes the missions for urban recon patrols.

(iii) Hardware Screening for Urban Recon Patrols - The patrol classification presented and the discussion can give immediate answers to some important questions of hardware. All patrols will have an upper limit of weight that is feasible for them to carry. However, it may well be the best choice to stay much below this level in order to increase the mobility of the patrol. A trade-off in weight for mobility when employing the small unit intelligence gathering patrol will usually be a good buy. On the other hand, an armored fighting patrol would probably not want to trade-off firepower for increased mobility. As a simple example of rank ordering of armored vehicles for an armored fighting patrol the British Alvis Saladin Mark 2 is superior to the FV 603 and the Mark 4 because it can deliver more fire than these vehicles. It also weighs more and is thus able to overrun street barricades better. In an effort to consider current and future hardware for urban recon patrols, the missions already derived have been matched against promising hardware (Table 17).

This list is qualitatively generated as described in the introductory remarks to this section. It is difficult to give detailed discussions on the role and use of certain hardware items such as

URBAN RECONNAISSANCE PATROLS

- Exclusively Intelligence Gathering
  - Small unit foot patrols
- Fighting Patrols
  - Vehicle base (Tank & APC)
  - Foot Patrols (usually with scouts)

- Determine enemy troop concentrations, both short (3-4 blocks) and long range (up to 10 miles).
- Take enemy prisoners.
- Serve as advance fighting units in an assault.
- Establish a presence, show the flag.
- Reconnaissance by fire from vehicles.
- Determine general situation (short range), possible threat and sniper locations.

Figure 55: Missions for Urban Recon Patrols

Table 17: Urban Recon Patrols

Mission (from figure V-55)	Promising Hardware (rank ordered)
Detect Troop Concentrations:	
Short Range	RPV, Dual Purpose Individual Weapon (M203)
Long Range	Improved Communications with HQ, Laser Range Finder, Small Laser Flasher to Bring in Mortar & Artillery Fire, Night Vision Devices
Capture Enemy Prisoners	Small caliber silenced weapon, incapacitating dart gun
Advanced Assault Unit	Heavy APC with large quantities of Firepower available, Plastic bubble for tanks, Smoke capability on vehicle hull.
Show of Flag	Improved Individual body armor (especially leg protection), fixed burst individual weapon.
Recon by Fire	(Rarely used) Tank round to destroy bldgs (by collapse rather than repeated fire), same for APC
Threat & Sniper Location	RPV

sensors because nothing has been done on this subject. In fact, material for urban patrols was widely scattered, and even first-cut studies on the subject were superficial -- merely mentioning that they were probably important.

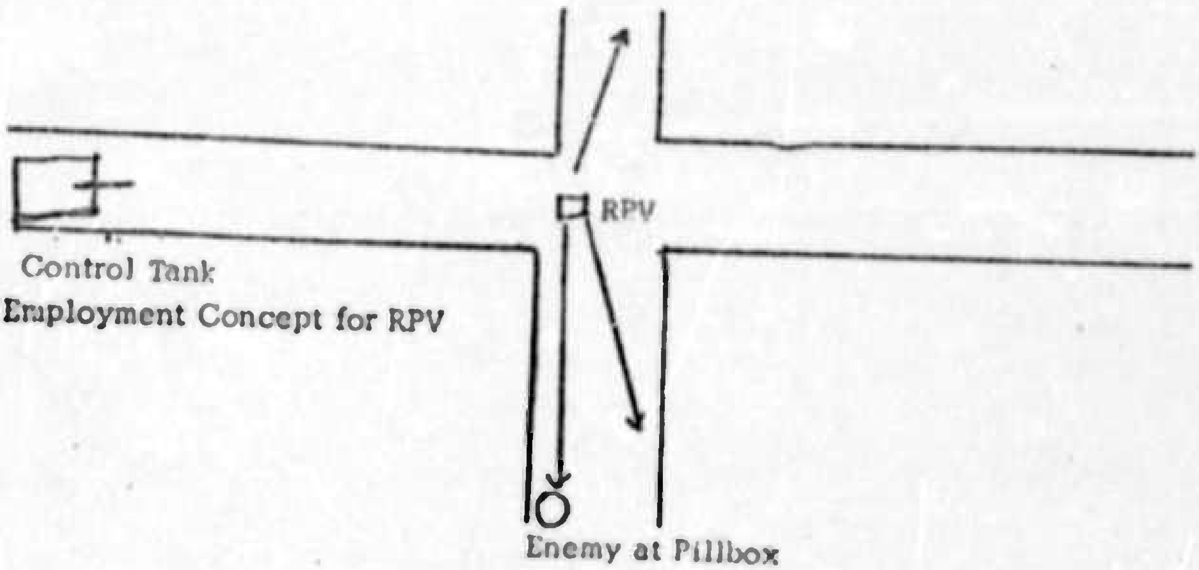
(iv) Remotely Piloted Ground Vehicles - Since this item is the most esoteric piece of hardware suggested for urban recon patrolling it is felt that an elaboration is needed. Research will continue on this item in the next year's effort but research to date indicates that it is indeed a high pay off piece of equipment. Most of the reasoning against such a system comes from a lack of understanding that urban patrolling is not a single mission. Several quite different missions can be demanded of a military force operating in a urban area.

Possibly the first ground RPV used in combat was a German machine that was used quite successfully in putting down the Warsaw rising of 1944. It was also used at Kursk and Budapest. Apparently they were quite cheap as they were used by the hundreds.

The system envisioned would be used for short range reconnaissance, say two to four blocks. It would have mounted on it a television camera that could scan the buildings. Ideally, line-of-sight would be maintained between the RPV and the operator. Longer ranges could be achieved with inexpensive tactical changes rather than costly hardware modifications. The design of the short range RPV should be such that it could be operated from within conventional tanks and armored personnel carriers. Thus the RPV could lead a tank by 1500 feet and both systems could thus patrol or penetrate a fairly large area. Possibly several RPVs could be controlled from a single piece of armor.

The RPV could look down side streets for enemy street level bunkers and troop concentrations. Pillboxes

are built on streets to fire at enemy armor more frequently than is generally acknowledged. The RPV would detect these positions. Because of its small size, the RPV will make a rather difficult target. Studies to determine quantitatively how vulnerable such a system is will be undertaken in next year's work. However, it should be noted that if an RPV is not available, tanks must be used and by any standards the loss of a tank will be much greater than the loss of an RPV. The RPV would be 4 feet long, 2 1/2 feet wide and 1 1/2 feet tall. It probably will require armor protection to make it immune from small arms fire.



Employment Concept for RPV

A summary mission list for RPVs in a built-up area demonstrates the need for a flexible system.

RPV MISSION LIST (BUILT-UP AREAS)

Ambush

Mobile bomb (satchel charge carrier)

Chemical agent deployment

Surveillance & short range reconnaissance

Draw fire

Detect mines

Barrier destruction

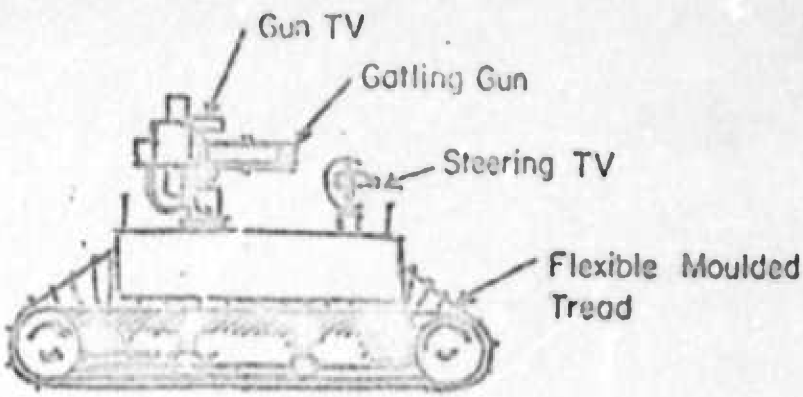
Lay communication wire (and barbed wire)

Smoke dispenser

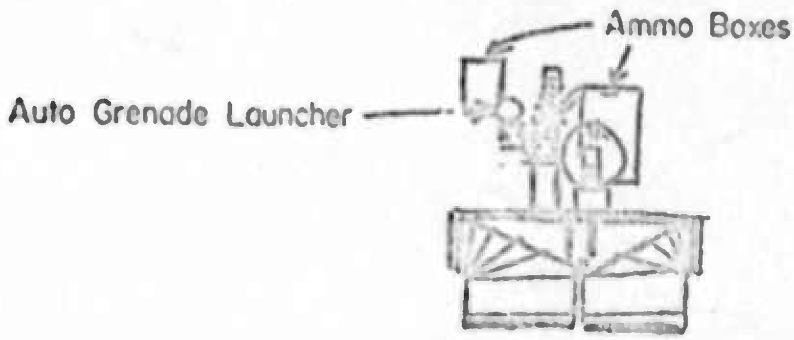
A system that is cheap enough to be disposable is needed. If necessary, sensor packages or explosives could be mounted on the vehicle and the entire system could then be detonated. This would be the extreme case. Most of the time the RPV would be used for reconnaissance, but the capability to destroy barricades should be built into the vehicle.

Another feature of RPVs for use in urban areas is that the cost is low because of the short ranges involved. The present assessment of state-of-the-art technology in this field indicates the cost begins to rise rapidly when the RPV has to travel great distances. This is because simple remote control methods fail to work beyond line-of-sight with the operator. Beyond this range the system must be remotely manned. The cost of this can force the system price up drastically. For the short ranges found in urban conflict, simple remote control technology appears to be more than adequate. Some sketches of RPVs are displayed on the next few pages, the drawings come from a TACTEC report on these systems. (Figures 56 and 57).

(v) Force Mixing - The quantities of certain pieces of equipment (including weapons) for the RPVis a problem that can and should be determined in next year's effort. This year's effort has provided a good baseline on the problems and limitations involved. Concentration by mission breakdown of quantitative benefits received from the list of high pay off hardware is now in order. These trade-offs



SIDE VIEW



FRONT VIEW

Note: This tread is designed to provide maximum traction while at the same time presenting minimum width and the lowest center of gravity possible.

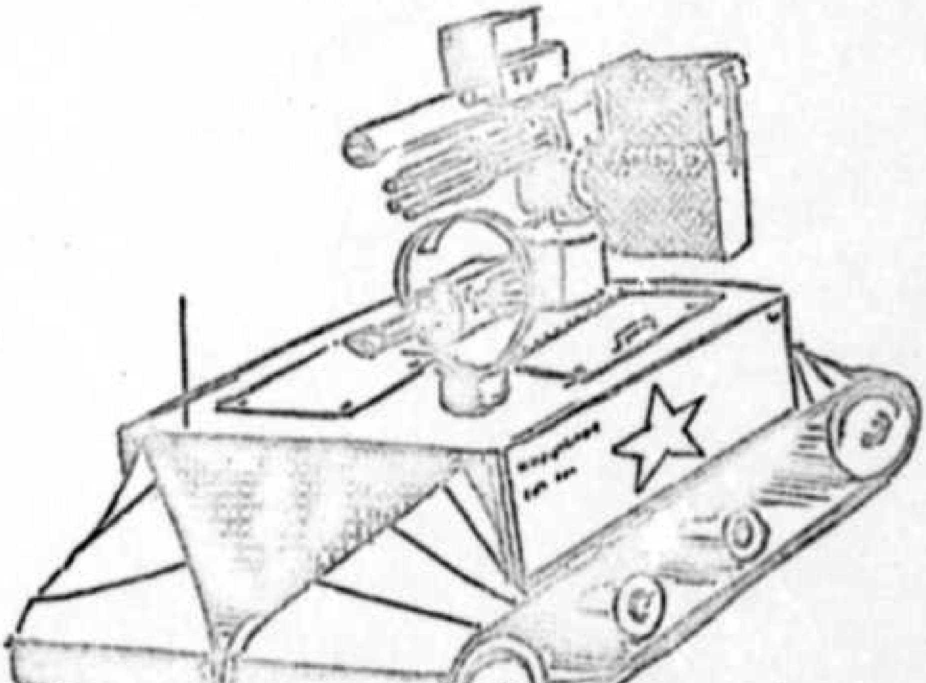


Figure 56: Mini-Remote-Controlled Patrol and Attack Vehicle

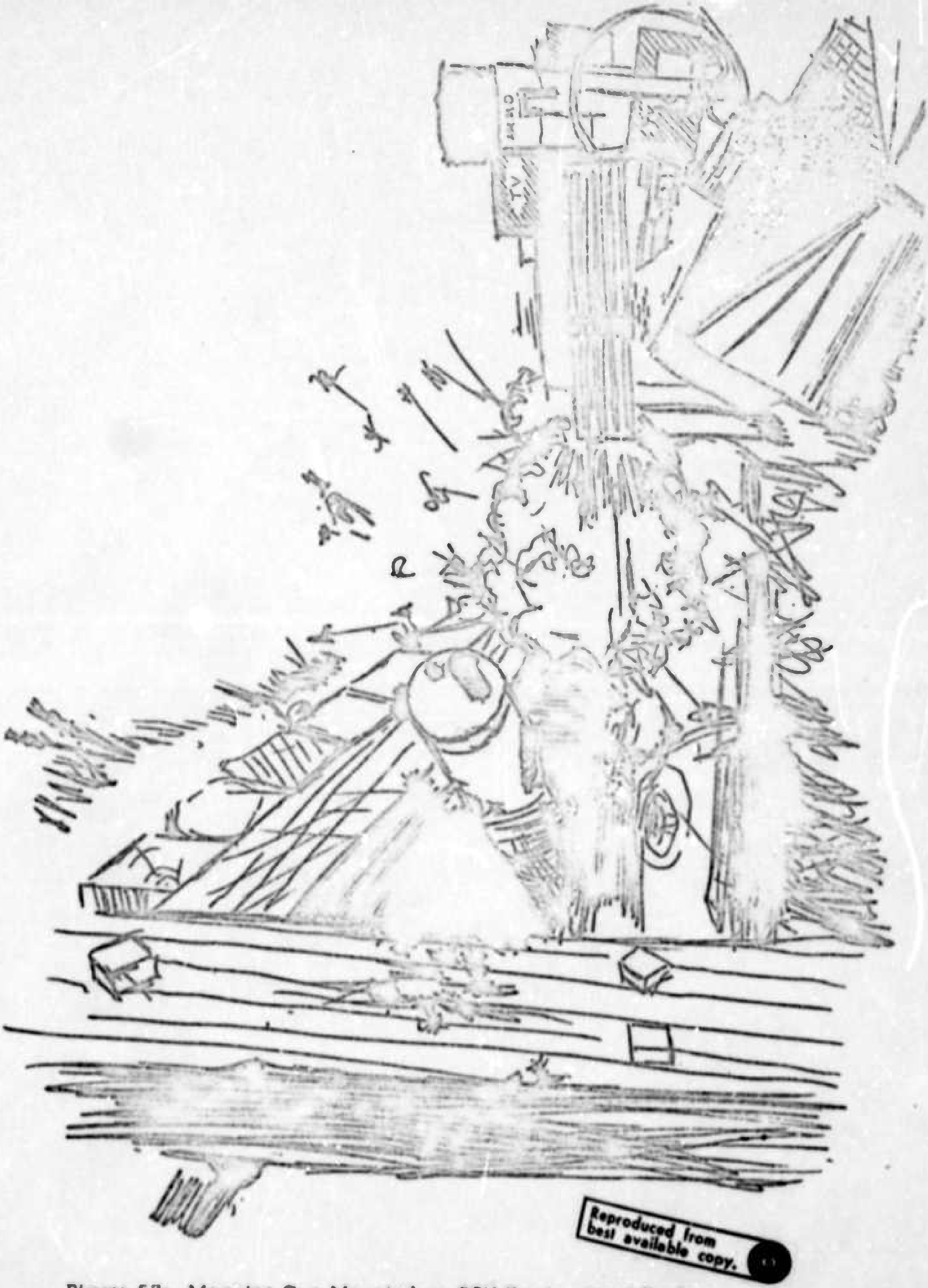


Figure 57: Macnine Gun Mounted on RPV Destroying a Bunker

will use existing models and techniques plus additional modeling that has been started for this specific purpose.* In addition, some computations for selected problems must be performed. In this area are the vulnerability of the RPV for various missions and certain effects of different scout and patrol deployment. An attempt is being made to deploy scouts in a pattern that will maximize (or at least improve) the total area visible to the unit. This has to be balanced against letting scouts stay too close or too far from the main patrol. Also in this area of research, is the need to consider the best headway distances between fighting reconnaissance vehicles. This particular problem will throw light on spatial formations for attack forces and design criteria for the electronic equipment to be mounted on an RPV.

(6) Urban Reconnaissance Patrols -- Findings and Recommendations

(i) Reconnaissance patrols are a primary means of obtaining combat intelligence in the city, yet U.S. doctrine regarding urban reconnaissance patrols is superficial. A comprehensive examination and delineation of mission activities, organization, and equipment for urban reconnaissance patrols has not been developed.	(i) More emphasis is necessary on the employment of urban reconnaissance patrols in built-up areas. An investigation of possible missions for urban reconnaissance patrols and the mixes of personnel and equipments required to accomplish those missions should be undertaken.
(ii) Remotely Piloted Vehicles hold considerable potential for rapid, three-dimensional reconnaissance in urban environment.	(ii) RPVs currently under investigation should be evaluated analytically and empirically to determine the feasible limits of their

* "A Mathematical Approach to Force Mixing" by Ronald D. Klein, ORA, Inc.

operability in the urban terrain and their value in the target acquisition and damage assessment roles.

IV.4.2 Air Assault Operations in Urban Areas

(1) Concept Description - Heliborne attacks on rear areas in city fighting are a complicated form of seizing key areas and of disrupting enemy freedom of movement. Though promising, these operations seem to draw severe criticism from Vietnam era tacticians. The chief variety of criticism is employed in pointing out the extreme vulnerability of helicopters flying over buildings. It is quite probable that the helicopters will be unable to detect threats until they are actually fired upon. Because of this and the additional complications involved in tactics for landing zone (LZ) preparation, the use of heliborne assaults in built-up areas has appeared to be another speculation that remains untested and unanalyzed. Although helicopters in this mode of operation are basically a means of achieving mobility, they are also of intrinsic importance to firepower systems and employment methods. The mobility aspects of this problem rightly belong to Calspan, Inc., however, a few considerations of these operations will be looked at here.

Air assaults on cities are not new. Contrary to the litany of reasons why cities do not make good targets for these missions, there remains the success of the German attacks on the airfields in Rotterdam. The Dutch had concentrated their defensive forces on the city suburbs and were completely disjointed by the rear area assault. In addition, the Dutch quickly lost control of the key bridges in the city. This had the effect of reducing their freedom of movement and permitted further German landings on the captured airfield. We have an example of a rear area attack that seized bridges, key buildings and the city airport.

In the Santo Domingo operations of 1965, heliborne attacks on enemy rear areas were considered. Apparently, the planning for these operations was carried out but actual usage was not implemented.

A brief look at certain Warsaw Pact military writings shows that they seem to be sympathetic to the use of heliborne assaults in a quick European war. An interesting point in favor of such tactics is that they consume relatively few troops compared to a prolonged street fighting battle. Another aspect of their use is that the defender (in this case NATO forces) would be quite unlikely to respond with tactical nuclear weapons since he would be destroying his own cities and population. Successful occupation of several European cities along the main line of attack of the front forces could contribute considerably to the increased tempo of a Warsaw Pact Offensive.

Numerous studies of helicopter employment in this mode of operation have been performed. The key difference for present needs is the environment under consideration. Separate study and development of helicopter air assault operations in cities are needed to complement existing studies on helicopters.

(2) Air Assault Operations in Urban Areas -- Findings and Recommendations

(1) Rear area airmobile assaults offer possible alternative options to slow block-by-block clearing of a built-up area. However, the tactics for airmobile offensive operations in cities have not been considered, and it is possible that the geometry of urban structures may force significant modifications upon conventional methods of airmobile assault developed in standard field environments.

(1) An extensive and detailed analysis of helicopter employment in urban airmobile assault operations should be undertaken.